# AIR QUALITY

## NORTHWESTERN ONTARIO

## Annual Report, 1980



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Ministry
of the
Environment

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## SUMMARY

This report presents results of the air quality assessment programme in northwestern Ontario in 1980. It includes data from eight communities in the region where long-term monitoring surveys were active during the year, plus summaries of special investigations in the Thunder Bay area.

### ATIKOKAN

Concentrations of suspended particulate matter, measured at the Atikokan Weather Station, continued to be generally acceptable.

Planning neared completion for a comprehensive pre-operational environmental monitoring programme in the vicinity of the Ontario Hydro thermal generating station under construction north of Atikokan. This investigation is being integrated with studies of acidic precipitation in the Quetico Provincial Park area, along the international border.

### BALMERTOWN

Vegetation and snow sampling showed that moderately elevated arsenic levels persisted in an area on company property around two gold mines at Balmertown. Air quality data, and samples from street trees and residential vegetable gardens indicated, however, that arsenic was at or near normal concentrations in the townsite.

The number of sulphur dioxide readings above maximum acceptable limits declined in 1980, probably because of termination of ore roasting at one of the mines. There were, however, a sufficient number of high concentrations to cause scattered vegetation injury over a 9-hectare area.

A proposal to abate sulphur dioxide emissions from the one remaining source is now under review by the Ministry.

DRYDEN

Dustfall continued in substantial compliance with Ontario regulations, as a result of control equipment commissioned at a local kraft pulp mill in 1977.

Concentrations of offensive odours frequently exceed the Ministry guideline. Provisions of a control order specify that emissions of reduced sulphur compounds, the cause of the odour problem, must be abated by mid-1984.

FORT FRANCES

In the vicinity of a kraft pulp mill in Fort Frances, vegetation damage was still evident in 1980, but in a smaller area than previously recorded. Fallout of particulate matter and the presence of malodorous gases continued to be a problem, but there was evidence of improvement from earlier years, particularly with respect to odour levels. The current control order specifies that Ontario standards for these two pollutants must be met before the end of 1983.

Some vegetation injury was also found near the lagoon area of the mill's secondary treatment system. Operations of this system have been altered to control the release of foam and spray, but unpleasant odours from the system's settling basins may persist until odour controls at the mill are completed.

KENORA

Fallout of bark char and lignite ash from a pulp and paper mill boiler plant continued to be an occasional nuisance to area residents. This problem is to be corrected by early 1982.

If the present sulphite-groundwood mill is converted to a combination thermal mechanical and chemical mechanical process, as now proposed, emissions of sulphur dioxide would be significantly reduced. Discharge of this contaminant, though well controlled now, has caused vegetation damage in the past.

## MARATHON

Monitoring in 1980 documented the continuing decline of mercury in air and soil near a former chlor-alkali plant at a kraft pulp mill. Snow samples demonstrated that emissions of sodium and sulphate from the mill significantly decreased after a new recovery furnace commenced operations. Mill emissions of particulate matter have never had significant impact in the townsite area, as dustfall monitoring, moss exposure trials and snow sampling have shown.

Average concentrations of offensive odours also decreased substantially with the commissioning of the recovery furnace.

## RED ROCK

Based on dustfall measurements and data from sulphation plates, fallout of particulate matter and concentrations of offensive odours continued to be well above acceptable levels in the vicinity of a kraft pulp mill in Red Rock. A new recovery furnace, now under construction at the mill, should result in significant improvement in local air quality by 1983.

## THUNDER BAY

Dustfall, at 11 of 13 sites, and total suspended particulate matter, at 5 of 6 sites, met the provincial air quality objectives for annual averages. This achievement is the result of a long-term, multi-million dollar dust control programme at local grain elevators, which has decreased dust levels in the city's air by about 40% to 50% in the past 7 years.

For the first time since measurements began in 1973, none of the maximum acceptable limits for sulphur dioxide (1-hour, 24-hour, or annual) were exceeded at any of the nine monitoring locations.

Total reduced sulphur near a kraft pulp mill violated the Ministry guideline 90 times in 1980. A control order will require appropriate odour emission abatement at this source by early 1984.

Summaries are provided for several special studies conducted during the year in the Thunder Bay area.

# INTRODUCTION

## PURPOSE OF MONITORING PROGRAMME

The Ontario Ministry of the Environment operates an air quality assessment programme throughout the province to measure the levels of air pollutants that may adversely affect human health, animals, vegetation, and the use and enjoyment of property. This programme documents compliance with air quality objectives, evaluates the effectiveness of pollution controls, and determines long-term trends in air quality.

In northwestern Ontario, the first monitoring device was installed in the City of Thunder Bay in 1963 to measure concentrations of suspended particulate matter. Since then, monitoring capability has expanded to seven pollutants, and the network has increased to over 90 instruments in eight regional communities. Ontario Hydro also operates comprehensive monitoring networks in Thunder Bay and Atikokan. Data from air quality instruments are supplemented by information from vegetation, soil and snow sampling studies, and by predictions of pollutant concentrations with mathematical models.

Monitoring in the region is concentrated in urban areas, in areas where there have been pollution problems in the past, and in the vicinity of industrial sources of air pollution (mining, and pulp and paper). Therefore, evidence of undesirable air quality cited in this report should not be interpreted as typical of the region as a whole, where air quality is generally excellent.

In recent years, acidic precipitation has become a major environmental issue in eastern North America and parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study (APIOS) has mounted a comprehensive, long-term study to assess the effects

and possible solutions to this problem. The Ministry's Northwestern Region is an active participant in this programme and is involved in precipitation sampling surveys and research on the aquatic and terrestrial effects of acid rain.

Future objectives of the air quality assessment programme in northwestern Ontario are to expand the monitoring network to all communities where pulp and paper mills are situated, to upgrade the collection and processing of air quality data, and to develop monitoring by some of the Ministry's clients.

## POLLUTANTS AND THEIR MEASUREMENT

In this section, only those contaminants routinely monitored in northwestern Ontario will be considered. Carbon monoxide, nitrogen oxides and hydrocarbons are not presently measured, nor are exotic organic compounds. On special request, many of the more unusual pollutants can be monitored by the Ministry's Air Resources Branch.

There are many man-made and natural sources of particulate matter. Typical man-made sources in this part of the province are grain elevators, forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Naturally-occurring particulate matter may also originate from forest fires, volcanic eruptions, and dust storms. Depending on particle size and chemical makeup, particulate matter may be injurious to health and vegetation and may also adversely affect visibility and cause local nuisance problems. In northwestern Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), or soiling index.

Dustfall represents fallout of particulate matter that settles out from the atmosphere by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed. The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ days (grams per square metre for 30 days), and the objective for the annual

average is 4.6 $g/m^2/30$ days. Suspended particulate matter comprises particles of small size which remain entrained in the air for extended periods. It is measured for a 24-hour period every sixth day with a standard high-volume sampler (1). The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air) averaged over 24 hours, or 60 $\mu g/m^3$, annual geometric mean. Soiling index is a measure of the soiling or darkening properties of suspended particulate matter. A measured volume of air is drawn through a paper tape which is advanced through an automated sampling unit to produce a sample every two hours. The reduction of light transmitted through the tape is expressed as a coefficient of haze (COH) per 1000 linear feet of air sampled. The Ontario objective is 1.0 COH for 24 hours, and 0.5 COH, annual average.

Gaseous pollutants currently monitored in northwestern Ontario include sulphur dioxide, total reduced sulphur, fluoride, and ozone. Sulphur dioxide ($SO_2$) is one of the world's major atmospheric pollutants and has many well-documented adverse effects on human health, vegetation and property. It is also one of the principal contributors to the formation of acidic precipitation. In northwestern Ontario, the principal sources, which are small in comparison to other areas of the province, are the Ontario Hydro Thunder Bay generating station, sulphite pulp mills, industrial boilers and gold ore roasting. $SO_2$ is monitored either with passive samplers (sulphation plates), which provide a semi-quantitative estimate of the presence of sulphur-containing gases, or with continuous analyzers which measure sulphur dioxide specifically. There are three air quality objectives for this pollutant: 0.25 ppm (parts of sulphur dioxide per million parts of air), hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

Total reduced sulphur (TRS) comprises a group of sulphur-containing gases commonly associated with emissions from kraft pulp mills, which are the sole significant TRS source in the

region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary respiratory irritation or may injure vegetation. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air) is used as an air quality objective in the vicinity of kraft pulp mills. Measurement of TRS is conducted with sulphation plates, for semi-quantitative results, or with automated analyzers to record TRS continuously.

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a secondary product of reactions between nitrogen oxides and hydrocarbons and, if present at elevated concentrations, may be detrimental to health and injurious to vegetation. Since the ingredients for ozone formation are not emitted in large quantity in northwestern Ontario, the occurrence of elevated ozone readings would implicate long-range transport from a distant source outside the region. Ozone is monitored with continuous analyzers and the current air quality objective is 0.08 ppm, averaged over one hour.

In northwestern Ontario, a brick and tile manufacturing facility near Thunder Bay is the only known industrial source of airborne fluoride. Fluoride may cause vegetation damage or injury to livestock which has consumed forage with high fluoride content. Fluoride in air is monitored with passive samplers (lime candles) which provide an estimate of average monthly fluoride levels. The amount of fluoride formed by the interaction of hydrogen fluoride with lime-impregnated filter paper is expressed as µg F/100 $cm^2$/30 days (micrograms of fluoride per 100 square centimetres of filter paper exposed for 30 days). The air quality objective is 40 µg F/ 100 $cm^2$/30 days for the growing season (May to September) and 80 µg F/100 $cm^2$/30 days for the rest of the year.

The presence and effects of some of the foregoing pollutants, as well as additional ones, are also assessed by documenting vegetation injury symptoms and by determining contaminant concentrations in vegetation, moss, soil and snow. Standard

Ministry procedures (2, 3, 4) are followed in the collection and analysis of these types of sample material. Arsenic, chloride, fluoride (5), sulphur and heavy metals are typical contaminants examined by these techniques. Concentrations determined by analysis are compared with known normal background levels for the element under study.

Dustfall and suspended particulate matter determinations, as well as most analyses for vegetation, moss, soil, and snow are performed at the Ministry's Thunder Bay laboratory. Metals, nitrate and sulphate in suspended particulate matter, and sulphur and halides in moss, vegetation and soil are analysed at the central laboratory in Toronto. The central laboratory also provides a service for the determination of unusual contaminants (e.g. some organic compounds).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality data for the region.

## ATIKOKAN

A long-term joint monitoring programme involving the Ministry, Steep Rock Iron Mines Limited and Caland Ore Company Limited (6) was terminated in 1979, shortly before permanent closure of the two mines. The only surviving part of this survey in 1980 was the continuation of measurement of suspended particulate matter (TSP) at the Atikokan Weather Station.

### AIR QUALITY DATA

During the year, the 24-hour air quality objective for TSP (120 $\mu g/m^3$) was exceeded in eight of 56 samples, and the maximum value was 375 $\mu g/m^3$, recorded on June 20. Most of the high readings occurred in the spring and early summer, during a period when road construction was in progress nearby. The annual geometric mean was 38 $\mu g/m^3$, well below the maximum acceptable limit of 60 $\mu g/m^3$, but slightly higher than the means from 1975 to 1979.

## ONTARIO HYDRO GENERATING STATION

Preparations reached the final stage to commence, in 1981, a comprehensive pre-operational monitoring programme in the area surrounding the Ontario Hydro thermal generating station now under construction just north of Atikokan. By 1984, when the first 200-megawatt unit of the 400-megawatt plant is scheduled to be commissioned, at least 3 years of background data on air quality, water quality, vegetation and soils will have been collected. This environmental assessment will continue for some years after the station begins operation. The Ministry fully anticipates that this investigation, jointly conducted with Ontario Hydro, will demonstrate that all environmental regulations and guidelines are being met.

## ACIDIC PRECIPITATION

Because of strong concerns expressed about the effects of the Atikokan generation station on sensitive wilderness areas along the Ontario-Minnesota border, a significant portion of the Ministry's regional study of acidic precipitation is concentrated south of Atikokan in the vicinity of Quetico Provincial Park and the adjacent Boundary Waters Canoe Area in Minnesota. Three sites are under consideration for the measurement and analysis of daily and monthly precipitation. Near these sites, and in one or two other locations in the area, vegetation and soil studies will be carried out to determine the terrestrial effects of acid rain. Sampling of many of the area's lakes, to determine their sensitivity to acid precipitation, was undertaken in 1979 and 1980. Lake sensitivity assessment will continue in 1981, and other biological studies, including fish sampling, will also be carried out.

## BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines at Balmertown since 1971 (7). For many years, Campbell Red Lake Mines Limited and Dickenson Mines Limited emitted signifi-

cant quantities of arsenic trioxide and sulphur dioxide from ore roasting operations. In the mid-1970's, both mines installed controls to reduce arsenic emissions by more than 95 percent. In early 1980, Dickenson implemented process changes which permitted the permanent suspension of ore roasting at its mill.

## VEGETATION AND SOIL ASSESSMENT

### Forest Area

Symptoms of acute sulphur dioxide ($SO_2$) injury were observed during the 1980 growing season on foliage of several kinds of trees, shrubs and herbaceous plants in small scattered areas on company property near the mines (Figure 1). Vegetation on residential property in the Fourth Street/Lassie Road area was also affected. The injury zone comprised about 9 ha (hectares) in total. In 1979, no $SO_2$ injury was found, and in 1978 there were 12 ha injured. Evidently, $SO_2$ damage is very variable from year to year, and depends on the right combination of pollutant concentrations, period of exposure, time of year, vegetation sensitivity, and other factors. Arsenic injury symptoms were not observed in 1980 and have not been seen since 1975.

Samples of trembling aspen foliage from 26 sites (Figure 2) were analysed for arsenic and mercury. The data for arsenic, plotted in Figure 3, show that elevated arsenic persisted around both mines. The concentrations found near Dickenson Mines were unexpected, in view of the shut-down of Dickenson's roaster early in the year. A comparison with results from earlier years (Table 1) indicates that levels in 1980 were well below those found in 1975 and earlier, when some form of controls were in place, but still well above normal background. In the past few years, there has been an increase in arsenic at some sites, instead of the decrease expected. Arsenic in forest trees at the perimeter of the townsite was near normal.

Mercury in aspen foliage was significantly elevated above normal only in a small area east of Campbell's roaster, where high values had been recorded in snow samples in 1978 and 1979

(7). The highest reading, 2.4 ppm, was approximately 60 times the mercury in the control samples. Concentrations off company property were at or near normal.

Samples of forage and soil were collected from a recently vegetated mine tailings area near Highway #105, a few hundred metres southwest of Balmertown. Arsenic levels were about 7 µg/g (micrograms of arsenic per gram of sample, dry weight) in the forage, in contrast to 11,000 µg/g (average of two samples) for the tailings soil at the same location. This finding confirms that vegetation growing on soil containing high levels of arsenic trioxide translocates virtually none of the arsenic to its foliage.

Townsite Area

Foliage from white elm (*Ulmus americana*) and Manitoba maple (*Acer negundo*) trees planted along roads in the townsite were found to contain no significant levels of arsenic (Table 2). Compared with the period before controls, arsenic concentrations in street trees in Balmertown declined approximately 99 percent.

Soil and vegetables from three residential gardens in Balmertown were collected and analysed for arsenic and mercury. The results for arsenic, in Table 3, were similar to those for 1979: of the 11 samples of edible portions of garden vegetables, only two lettuce samples were slightly above the maximum limit specified by the Health Protection Branch, Canada Department of Health and Welfare. All other samples met the regulation. Since arsenic levels in soil remain high, vegetables from Balmertown gardens should be well washed before consumption. All sampled vegetables were well within the recommended international guideline for mercury.

## SNOW SAMPLING

A 15-site snow sampling survey was undertaken in February, 1980, around the two gold mines. Arsenic in meltwater from the samples was somewhat higher in 1980 than in 1979, but the concentration in the immediate vicinity of Campbell's roaster (a known

"hot-spot" in former years) was well below the level found in 1978 and 1979. Mercury had also declined at this location, but was still above normal background concentration at this and other sites in the area sampled.

## AIR QUALITY DATA

### Moss Exposure

Small samples of dried Sphagnum moss were exposed for 41 days at 28 sites at Balmertown during the late summer. Arsenic and mercury levels were then determined and compared with normal levels in two exposed and two unexposed controls. A plot of the data (Figure 4) reveals that arsenic was moderately elevated in the study area, particularly near Campbell Red Lake. Arsenic in all control samples was below 2 µg/g. No elevated readings were recorded for mercury, in contrast to results from vegetation and snow sampling.

### Suspended Particulate Matter (TSP)

Campbell Red Lake Mines operates a high-volume sampler on a 6-day schedule in the centre of Balmertown. Filters are routinely weighed to determine TSP and arsenic. Because of equipment malfunction, data are available only for the first 2½ months of 1980 (10 samples). During this period, very low concentrations of both TSP and arsenic were recorded, and all values were well within Ontario regulations.

### Sulphur Dioxide

A summary of the readings obtained from the Ministry's continuous $SO_2$ analyzer in Balmertown is presented in Table 4, together with data for previous years. In 1980, the one-hour air quality objective was exceeded 76 times, and the 24-hour objective six times. Both of these figures were down significantly from 1978 and 1979, probably because of the reduction in emissions following closure of Dickenson's roaster. The annual average concentration, 0.011 ppm, was also down from the mean of

0.016 ppm in 1979, and well below the maximum acceptable limit of 0.020 ppm. There was only one "potentially injurious fumigation" (PIF) recorded, on June 7. A PIF is defined as the occurrence, during daylight hours in the growing season, of average $SO_2$ concentrations at a level considered injurious to sensitive vegetation. In 1979, there were three PIF's, and in 1978 there were six. In 1980, most of the high $SO_2$ readings occurred in October, after the growing season.

At the concentrations recorded, sulphur dioxide might occasionally be noticed as a disagreeable odour by local residents, but no adverse health effects would be expected. Periodic injury to vegetation might occur. Campbell Red Lake Mines has completed a feasibility study on $SO_2$ control, which suggests that emission reductions, during periods in the growing season when $SO_2$ is carried toward the townsite, may be a practical approach toward abatement of the problem. A firm proposal will be submitted by the company for review by the Ministry.

## DRYDEN

For several years, the Ministry has monitored air quality in Dryden to assess the effects of emissions from a bleached kraft pulp mill and associated chlor-alkali chemical plant. Past studies demonstrated (8) that levels of mercury, particulate matter, and offensive odours in the vicinity of the mill were often significantly above normal. However, since vegetation sampling, moss exposure trials, and snow sampling showed, in 1979, that levels of mercury and particulate contaminants had declined to normal levels off mill property, no further work along these lines was performed in 1980. Vegetation was inspected, however, and there was no evidence of injury attributable to air pollutants.

### AIR QUALITY DATA

#### Dustfall

Eighty-eight percent of the monthly dustfall values at the six monitoring sites in Dryden (Figure 5) met the Ontario air

quality objective. The highest levels occurred in July, and were principally due to road dust or insect material. Except for relatively minor amounts of bark char, emissions from mill operations contributed very little to fallout of particulate matter in the town. The annual objective was met at all but one site. Sulphate in dustfall was consistently low. A comparison of annual averages over the past 5 years (Table 5) reveals that the emission controls installed at the mill in 1977 were very effective in reducing particulate fallout to acceptable levels.

Sulphation Rates

The historical record for sulphation rates in Dryden is summarized in Table 6. There has been no significant change in recent years. Experience indicates that a sulphation rate above about 0.20 mg $SO_3$/100 $cm^2$/day, which often occurred at sites nearest the mill, is evidence of unacceptably high concentrations of sulphur compounds in the air.

Total Reduced Sulphur (TRS)

Direct, continuous readings of total reduced sulphur are obtained by an automated analyzer at 56 King Street. A summary of the data (Table 7) supports the finding from sulphation monitoring that there has been no change in average concentrations in recent years. The many readings in 1980 above the guideline of 27 ppb demonstrated that concentrations of offensive odours frequently occurred at unacceptable levels. The maximum one-hour average during the year was 436 ppb, approximately 16 times the guideline. No significant improvement is expected until odour emissions from the mill are abated. These controls are to be in place by the end of June, 1984, to comply with provisions of a Ministry control order.

## FORT FRANCES

Emissions from a bleached kraft pulp mill in Fort Frances have resulted in excessive fallout of particulate matter, high

concentrations of malodorous gases, vegetation damage, and numerous complaints from nearby residents. Since 1971, when the kraft mill was constructed, a "buffer zone" has been developed through purchase of residential property. Attempts have also been made to reduce emissions and, in 1980, a control order was issued to enforce compliance with Ministry regulations.

Air quality assessment investigations in Fort Frances have been conducted regularly since 1972 (9). In 1980, this comprehensive programme was expanded to include the studies around the mill's secondary treatment system, which was a source of many complaints during the spring months of the year.

## VEGETATION ASSESSMENT

### Mill Area

Tree and shrub vegetation near the kraft mill was examined twice during the growing season, and the injury zone ascribed to mill emissions was judged to be 5.2 ha (Figure 6) in 1980, down from 6.6 ha in 1979, 9 ha in 1978 and 12 ha in 1977. Injury severity was also reduced, compared to preceding years. Despite this improvement, trees in the "buffer zone" area continued to decline, due to persistent exposure over several years to chlorine, reduced sulphur compounds, and other injurious substances emitted from the mill.

Sodium and chloride concentrations in Manitoba maple foliage sampled from 24 sites (Figure 7) are shown in Table 8. Sodium levels declined from 1979 to 1980 but remained high in the "buffer zone". Chloride concentrations increased. The strong correlation between sodium and chloride in Manitoba maple foliage ($r^2$=0.8-0.9) demonstrates that both contaminants originated from the same source.

### Lagoon Area

Air pollution injury to shrubs and trees was noted in the immediate vicinity of the south side of the mill's secondary treatment system (lagoon) area on Eighth Street, 1.5 km northwest

of the kraft mill. Black ash and willow on company property was damaged, and injury symptoms were evident on foliage of trees on a nearby residential property. Chemical analysis of injured foliage indicated that excess chloride in windborne spray from the lagoon was likely the primary cause of the damage. Operations at the lagoon have since been altered to significantly abate this problem.

## SNOW SAMPLING

Snow samples from 16 sites around Fort Frances were collected in February and tested for calcium, chloride, sodium, and sulphate content. Highest concentrations of these contaminants were found in the "buffer zone," and declined rapidly as distance from the mill increased. Results for earlier years were similar. As noted in the following discussion on dustfall, the high concentrations of sodium and sulphate in snow were probably due to excessive fallout of these compounds in January.

## AIR QUALITY MONITORING

### Dustfall

Monitoring results for 1980 (Table 9) at seven sites (Figure 8) show frequent occurrences of dustfall above monthly and annual objectives, particularly near the mill. Expressed as saltcake, sodium and sulphate accounted for up to 35 percent of average annual dustfall (Table 10). Saltcake in dustfall was very high in January, which no doubt resulted in elevated sodium and sulphate in snow samples collected the following month. Calcium in dustfall was low.

Examination of insoluble dustfall showed that wood fines constituted the principal component of particulate matter fallout near the mill. At station 63046, wood fines comprised about 60% of total dustfall. Comparable figures for stations 62036, 62033 and 62030 were 40%, 40% and 25%, respectively. There is little doubt that if wood fines and saltcake were removed, dustfall would substantially comply with provincial regulations. Despite

this long-standing problem, there was evidence of improvement in 1980. Average dustfall for all sites declined about 20% from 1979 to 1980. Because of interruptions in mill operations in 1975, 1976, and 1978, a trend analysis for dustfall could not be undertaken.

Suspended Particulate Matter (TSP)

Concentrations of TSP at the site nearest the mill (station 62030) exceeded the 24-hour air quality objective during 22 sampling periods in 1980. Wood fines, emitted from the mill's wood chip processing system, were frequently observed on sample filters. The annual geometric mean was 74 $\mu g/m^3$, somewhat above the level (60 $\mu g/m^3$) considered desirable. Most high values occurred in spring and early summer, during conditions of drought. At station 62032, some distance from industrial activity, the 24-hour objective was exceeded only twice and the annual mean, 41 $\mu g/m^3$, was similar to that recorded for several years at this location. Highest readings at both stations were associated with prevailing wind from the south.

A control order, issued in 1980, requires acceptable abatement of particulate emissions from the wood chip handling system at the Fort Frances mill by the end of 1983. In addition to further improvements on emission controls, mill management is negotiating an enlargement of its "buffer zone", to include residential areas where fallout problems are greatest.

Sulphation Rates

The 1980 data show improved air quality (Table 11). Average values declined approximately 44% from 1977 to 1980, indicating a reduction in odour-causing gases in the community. However, sulphation rates at sites close to the mill continued to be unacceptable, particularly early in the year.

Total Reduced Sulphur (TRS)

The TRS results for the year confirm the improvement noted for sulphation rates. Although there were many violations of the one-hour guideline of 27 ppb at station 62030, the frequency of

high concentrations was lower. The 872 hours over the guideline (Figure 9) represented 10% of the total number of hours of data. Comparable figures for 1979 were 911 hours (11%), and for 1978 were 1035 hours (14%). As shown in Table 12, the annual average near the mill (station 62030) declined from 16 ppb in 1978 to 9 ppb in 1980, a drop of nearly 45%. The highest TRS levels recorded near the mill might occasionally cause temporary discomfort to some local residents.

The frequency of TRS levels above the guideline at station 62032, in the Fort Frances Cemetery, has increased over the past few years, although the annual average has remained fairly constant. The data for the year are plotted in Figure 10.

Wind direction data (Table 13) indicate that the highest TRS readings occurred when the two monitors were downwind of the nearest major source. For station 62030, the notable reduction in TRS concentrations from 1978 to 1980 for wind blowing from 150-260$^{0}$, indicates that TRS emissions from the Canadian mill decreased significantly during this period. The low, but detectable, readings with north winds at station 62032 were attributed to odours from the secondary treatment system on Eighth Street.

As already noted, odour levels near the mill declined in 1980. Further abatement, required under the current control order, specifies compliance with Ontario regulations by the end of 1982. At the secondary treatment system (lagoon area) the foam and spray problem has been largely controlled by the addition of defoaming agents and re-arrangement of the sprayers. Odours from the settling basin may persist until 1983, when odour abatement at the mill has been completed.

## KENORA

Air quality studies have been conducted by the Ministry for the past 11 years around a sulphite pulp mill in Kenora (10). In the past, sulphur dioxide emissions from this source caused periodic vegetation damage, but this problem was corrected several years ago. Fallout of particulate matter from the mill's power boiler stack has continued as an occasional nuisance to nearby residents.

## AIR QUALITY DATA

### Dustfall

Dustfall in 1980 (Table 14) was generally acceptable for three of the four sites monitored (Figure 11). The exception was at station 61007, northeast of the mill, where the presence of bark char and lignite flyash caused frequent excursions above the monthly air quality objective. The maximum monthly dustfall at this location was 31.2 $g/m^2$ (about 4½ times the objective), recorded in December. Approximately 85% of the total dustfall in this sample was bark char. About 80% of the dustfall for the same month at station 61009 was also bark char. This contaminant was often visible in dustfall jars, particularly at station 61007. Abatement of particulate fallout is required by March, 1982, according to an existing Ministry control order. Bark char and lignite ash are neither a health hazard, nor injurious to plant life.

### Sulphation Rates

Although there was substantial loss of data in 1980, there were no excessively high readings and no evidence of significant change from other years. Although the existing mill might occasionally emit sulphur dioxide in excess of the Ministry standard, any potential problem from this pollutant should be resolved with the planned conversion of the mill, expected possibly by 1985, to a combination thermal mechanical and chemical mechanical process.

## MARATHON

Air quality investigations at Marathon, which began in 1974, have examined concentrations and effects of airborne mercury, particulate matter, and gaseous sulphur compounds in the vicinity of a bleached kraft pulp mill and adjacent chlor-alkali plant (11). All surveys showed that, with the exception of sulphur compounds, emissions from these sources had negligible impact in the townsite area, 500 to 1,000 metres to the east.

In 1980, monitoring continued to test for mercury residues following the closure of the mercury-cell chlor-alkali plant in 1977, and measurements were also made of particulate matter deposition and sulphation rates.

## VEGETATION AND SOIL ASSESSMENT

Two inspections during the summer failed to reveal any evidence of sulphur dioxide injury to vegetation. No visible $SO_2$ damage has been recorded near the Marathon mill since a tall stack was commissioned in late 1977. Deposits of whitish-coloured particulate matter, mostly from lime kiln emissions, were noted on vegetation and rocks on the hillside at the southeast corner of the mill.

Three depths of soil were collected from 10 sites (Figure 12) around the mill and analysed for mercury. The data (Table 15) show that mercury levels declined from 1976, the last full year of chlor-alkali plant operation, to 1980. The most notable decrease was in subsurface soil. High concentrations persisted in surface soil at one location near the chlor-alkali plant and at two points some distance from the mill (sites 32 and 33) where mercury contamination was found several years ago. Residual mercury is expected to continue its decline, and no measurable adverse effects are anticipated. Since repeated sampling has shown very low mercury concentrations in drainage water from contaminated soil near the mill, it is assumed that mercury reduction in this area had occurred by evaporation.

## SNOW SAMPLING

To determine the effects of a new, tall stack and a new recovery furnace on fallout of particulate matter, a set of snow samples was obtained in January for 15 sites around the mill and in the townsite (Figure 13). Compared with earlier years, there was little change in calcium levels, but chloride, sodium, and sulphate showed significant declines (Table 16). The reduction in sodium and sulphate was attributed to benefits from the new

recovery furnace, but the decrease in chloride was unexpected. The quantity of visible particulate matter in snow was also much less than that recorded for 1978 and earlier. Levels of all contaminants were low in the townsite.

## AIR QUALITY DATA

### Moss Exposure

The results from a 36-day exposure trial with Sphagnum moss at 10 sites (Figure 12) confirmed that airborne mercury concentrations near the mill and chlor-alkali plant dropped sharply since closure of the chlor-alkali operation in 1977 (Table 17). Except for one site, mercury levels in moss were at or near normal background concentration.

### Dustfall

The monthly air quality objective for dustfall was rarely exceeded in 1980. Notable exceptions were the months of April and June, where the presence of sand was responsible for high readings at station 63029 (Figure 14). Wood fibres were occasionally observed in dustfall jars at station 63027. The summary in Table 18 indicates no trend over the past 6 years. Since particulate emissions from the mill have no demonstrable impact on the townsite area, and since dustfall in the town substantially complies with Ontario regulations, monitoring was discontinued at the end of the year.

### Sulphation Rates

Average sulphation rates for 1980 (Table 19) reflect the environmental improvements implemented at the mill in late 1977 and early 1979. The average sulphation rate for five monitoring sites declined by more than 60% from 1978 to 1980.

According to a recent emission inventory, the mill meets all Ministry standards except those for particulate matter and, possibly, total reduced sulphur. By the end of June, 1981, the company must submit proposals to achieve compliance with all regulations by the end of 1984.

## RED ROCK

Surveys conducted since 1976 have established that a kraft pulp mill at Red Rock is a source of significant emissions of particulate matter and reduced sulphur (12). The Ministry maintains a small network of passive samplers in Red Rock to monitor local air quality (Figure 15).

### AIR QUALITY DATA

#### Dustfall

Table 20 summarizes dustfall results for 1980 at four sites in Red Rock. There were frequent high readings at two of the four stations, and dustfall met the annual objective only at the site farthest from the mill. Sodium and sulphate, expressed as saltcake ($Na_2SO_4$), accounted for 30% to 60% of total dustfall. Bark char, wood fibres, and insect parts constituted most of the remaining fraction. Bark char was often visible in dustfall jars at stations 63080 and 63082, and wood fibres were noted in samples from 63080 and 63081. A deposit of black liquor was conspicuous on the sides of dustfall jars facing the mill during December.

A new recovery furnace and precipitator, now under construction, is expected to significantly reduce emissions of particulate matter by the end of 1983, in compliance with a Ministry control order. In the meantime, particulate matter fallout will be a local nuisance, though not hazardous to health or toxic to plants.

#### Sulphation Rates

The concentrations of airborne sulphur compounds (reduced sulphur, in this case) persisted at high levels in 1980 during months when the townsite was downwind of the mill. The data for 1978, 1979, and 1980 were similar (Table 21). Under worst conditions, residents of Red Rock are exposed to odour concentrations sufficiently high to cause temporary discomfort. The new recovery furnace should result in very substantial improvement in odour levels in the townsite.

# THUNDER BAY

In 1980, the Ministry monitored air quality at 13 sites in the City of Thunder Bay, and obtained data for four kinds of pollutants. Ontario Hydro operated a network of sulphur dioxide monitors at an additional seven sites.

Several special studies were also undertaken during the year. Brief summaries of each of these investigations are presented in this report.

## AIR QUALITY DATA

### Dustfall

Dust emissions from grain elevators have historically been a nuisance problem in Thunder Bay, and dustfall measurements in the city began in 1970 with these sources in mind (13). The data for the 13 sites monitored in 1980 (Figure 16) are summarized in Table 22. Although the monthly objective was exceeded once or more at seven of the 13 sites (10% of all samples), all but two locations (near Great Lakes Forest Products Limited) complied with the annual objective. Dustfall jars at these two sites sometimes contained visible quantities of bark char and wood fibre. Average pH of dustfall solutions was close to pH 4.0, except at Gore Street (station 63003) and at the two stations near Great Lakes (stations 63046 and 63047), where higher levels occurred. The lowest pH, 3.5, was recorded on Mission Island. It is hoped that data for dustfall pH may serve as an indicator of precipitation acidity and may help to identify local or regional sources of alkaline or acidic fallout. Table 23 and Figure 17 clearly show the benefits from the long-term, multi-million dollar dust control programme at the city's grain elevators. In the past 8 years, average dustfall has declined nearly 50%. At the nine sites where monitoring was conducted from 1973 to 1980, only one met the annual dustfall objective in 1973, but all sites were in compliance in 1980.

Suspended Particulate Matter (TSP)

Of the six sites where TSP was measured, five met the objective for annual geometric mean (Table 24). Approximately 10% of the 328 samples exceeded the 120 $\mu g/m^3$ 24-hour objective, with most of the high values occurring in the spring. Table 25 and the bar graph in Figure 18 show a trend similar to the one noted for dustfall: a progressive decline of approximately 40% in average TSP from 1973 to 1980. Now that the grain dust control programme is virtually complete, no significant changes are expected in local dust levels and no additional abatement programmes required. A plateau has probably been reached, with annual fluctuations anticipated from variations in climatic conditions.

Filters from two stations in the city centre (McKellar Hospital and St. Joseph's Hospital) were routinely analysed for heavy metals, nitrate and sulphate. All concentrations for metals (except iron in two samples) met Ministry regulations. Levels of nitrate and sulphate, thought due to long-range transport, exhibited much variation.

Soiling Index

Soiling index, measured at St. Joseph's Hospital and 435 James Street South, was well within prescribed limits for 24-hour and annual averages. Annual averages in Thunder Bay have shown little change since monitoring began in 1976.

Sulphur Dioxide ($SO_2$)

Total emissions of $SO_2$ from Thunder Bay sources (principally the Ontario Hydro generating station and pulp and paper mills) are relatively small, and do not exceed 100 metric tons per day. The network of nine monitors (seven operated by Ontario Hydro and two by the Ministry) showed, for the first time since measurements began in 1973, full compliance for all sulphur dioxide air quality objectives in 1980 (Table 26).

### Total Reduced Sulphur (TRS)

The Ministry's continuous monitor at Can-Car (station 63046) revealed that the TRS guideline was exceeded during 90 hours in 1980, compared with 26 hours in 1979 and 28 hours in 1978 (Table 27). The source of the TRS, which causes offensive odours, was a kraft pulp mill, 1100 metres from the monitoring site. The maximum one-hour TRS reading during the year was 131 ppb, well above the maximum of 50-60 ppb found in other years. The increased levels in 1980 were partially ascribed to mill operating problems, which have now been resolved. Figure 19 plots the hourly TRS for the year.

A recently completed emission inventory confirms that TRS discharges from the mill do not comply with the Ministry standard. As specified in the current control order, Great Lakes must submit a proposal by September 30, 1981, to upgrade its odour controls by the end of March, 1984.

### Ozone ($O_3$)

Ozone monitoring began only in late November, 1980, at station 63040 (435 James Street South). For the single month of data, there were no concentrations above the air quality objective.

## SPECIAL STUDIES

### Pulp Mills

Vegetation assessment inspections were again conducted around the three sulphite pulp mills in Thunder Bay. No air pollution injury was found.

### Thunder Bay Terminals

A report on air quality studies in the vicinity of Thunder Bay Terminals Limited showed that the coal terminal was operating satisfactorily, and that there was no increase in dust levels off company property since coal shipments began in mid-1978 (14).

Thunder Bay Yacht Club

A special survey, from May to October, indicated that total dustfall, and iron and sulphur in dustfall, were not excessive on the property of the Thunder Bay Yacht Club. The club had expressed concern about windblown sulphur dust from a storage pile at Valley Camp Terminals Limited, on the side of Mission River opposite yacht club property. Since Valley Camp no longer receives and ships large quantities of elemental sulphur, no further complaints are anticipated.

Thunderbrick Limited

Results from investigations in 1980 demonstrated that a brick and tile manufacturing plant operated by Thunderbrick Limited, in Rosslyn, continued to emit airborne fluoride at concentrations injurious to sensitive vegetation on nearby residential property (15). The air quality objective for fluoride was also sometimes exceeded, but there was no evidence of a health hazard. A control programme is now being implemented to reduce fluoride emssions to acceptable levels.

PCB Investigations

The Ministry was involved in three investigations of PCB (polychlorinated biphenyl) compounds: a 4-week survey to determine normal background concentrations of PCB's in Thunder Bay, and two incidents where PCB-contaminated transformer oil was spilled. One of the spills involved release of fluid from a transformer outside a local school (16) and the other concerned the discharge of similar material from a transformer being processed on the property of a scrap metal dealer. Clean-up procedures at both sites were closely monitored by the Ministry.

Forest Fire Smoke

On June 26, smoke from a distant forest fire was present for several hours in Thunder Bay. Fortunately, June 26 was a scheduled sampling date for the six high-volume samplers in the city. The filters, after exposure, were black and emitted a smoky

aroma. Analysis showed that TSP levels were above average, but not excessive. Concentrations of some PAH (polynuclear aromatic hydrocarbon) compounds, known to cause cancer in animals, were slightly elevated but within the range considered normal for Ontario. It was concluded that there was no public health hazard from the presence of the smoke (17).

MacMillan Bloedel Industries

A snow sampling survey carried out in February showed that emissions of wood fines decreased sharply after a conical woodwaste burner was shut down at MacMillan Bloedel's waferboard plant, near Rosslyn Village (18). This action resolved a problem of fallout of particulate matter, which had been a nuisance to area residents for several years.

## ACKNOWLEDGEMENTS

The assistance of the following organizations is gratefully acknowledged: staff of the Atmospheric Environment Service, Atikokan Weather Station, for operating a high-volume sampler; Campbell Red Lakes Mines Limited for providing data on suspended particulate matter in Balmertown; staff of the Dingwall Medical Clinic, Dryden, for assistance in operating the TRS monitor; and Ministry of Industry and Tourism, Fort Frances, for assistance in operating the TRS monitor at station 62030.

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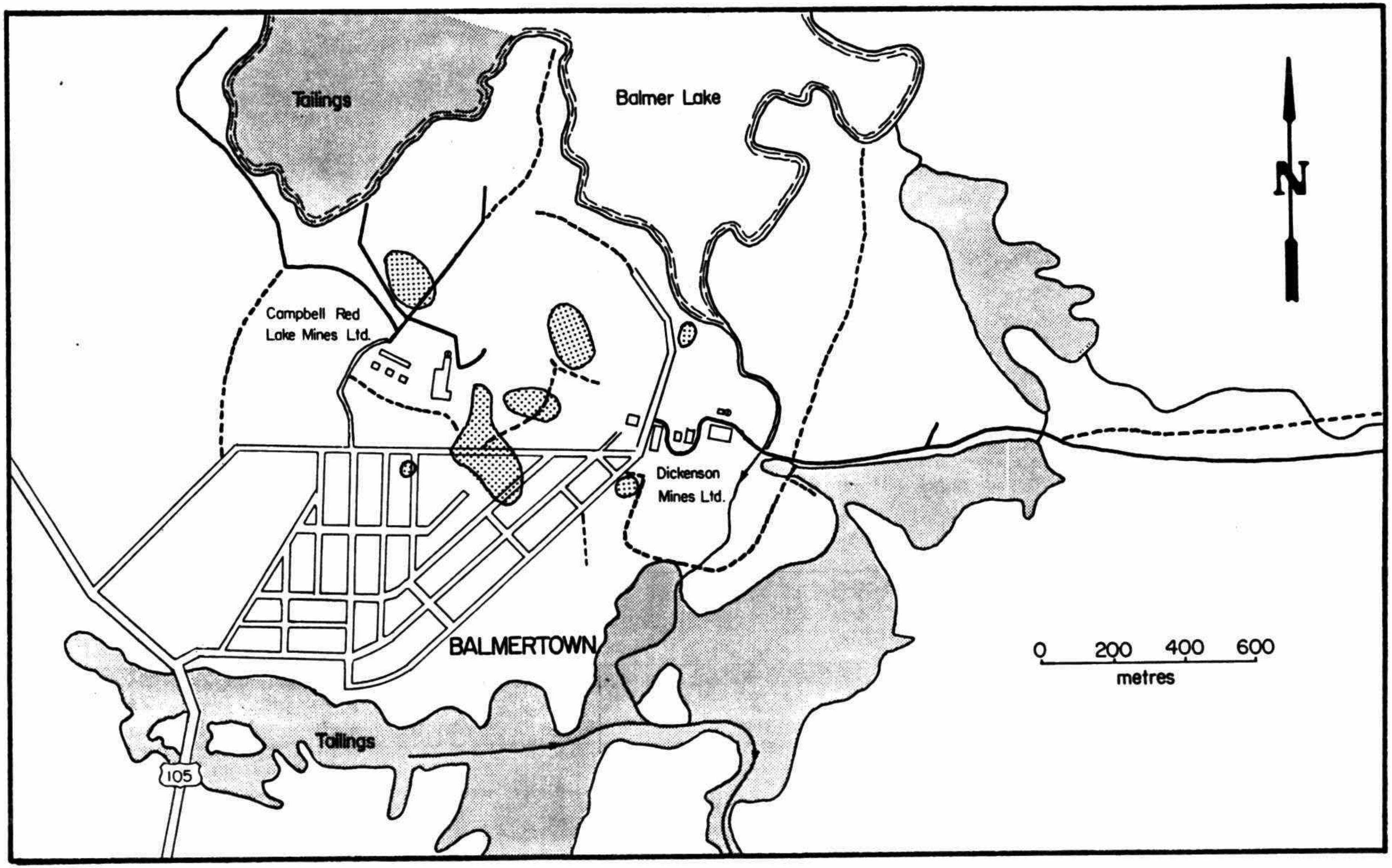



Figure I. Areas of sulphur dioxide injury to vegetation, Balmertown, August, 1980.

Injury zones

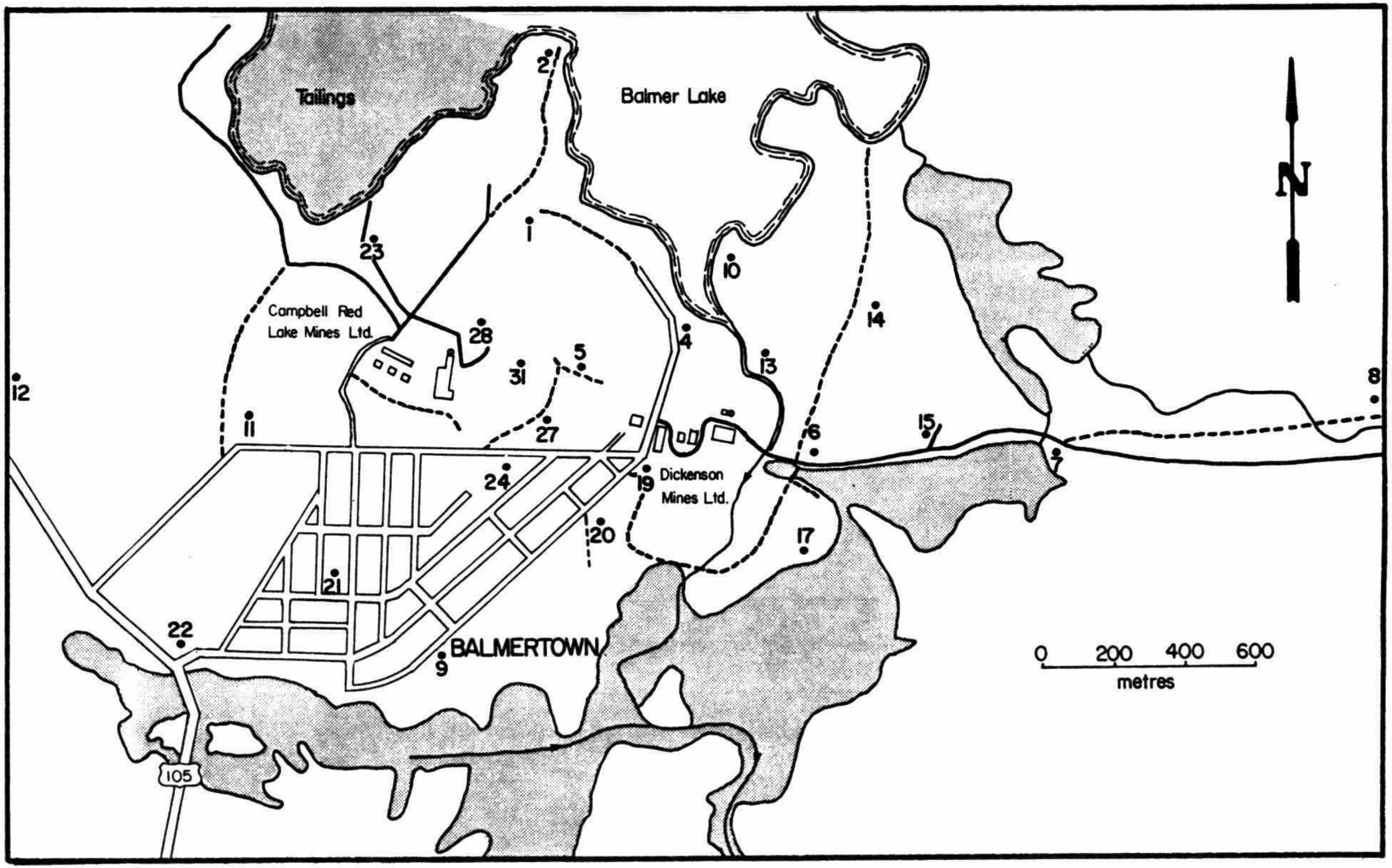



Figure 2. Trembling aspen sampling sites, Balmertown, 1980.

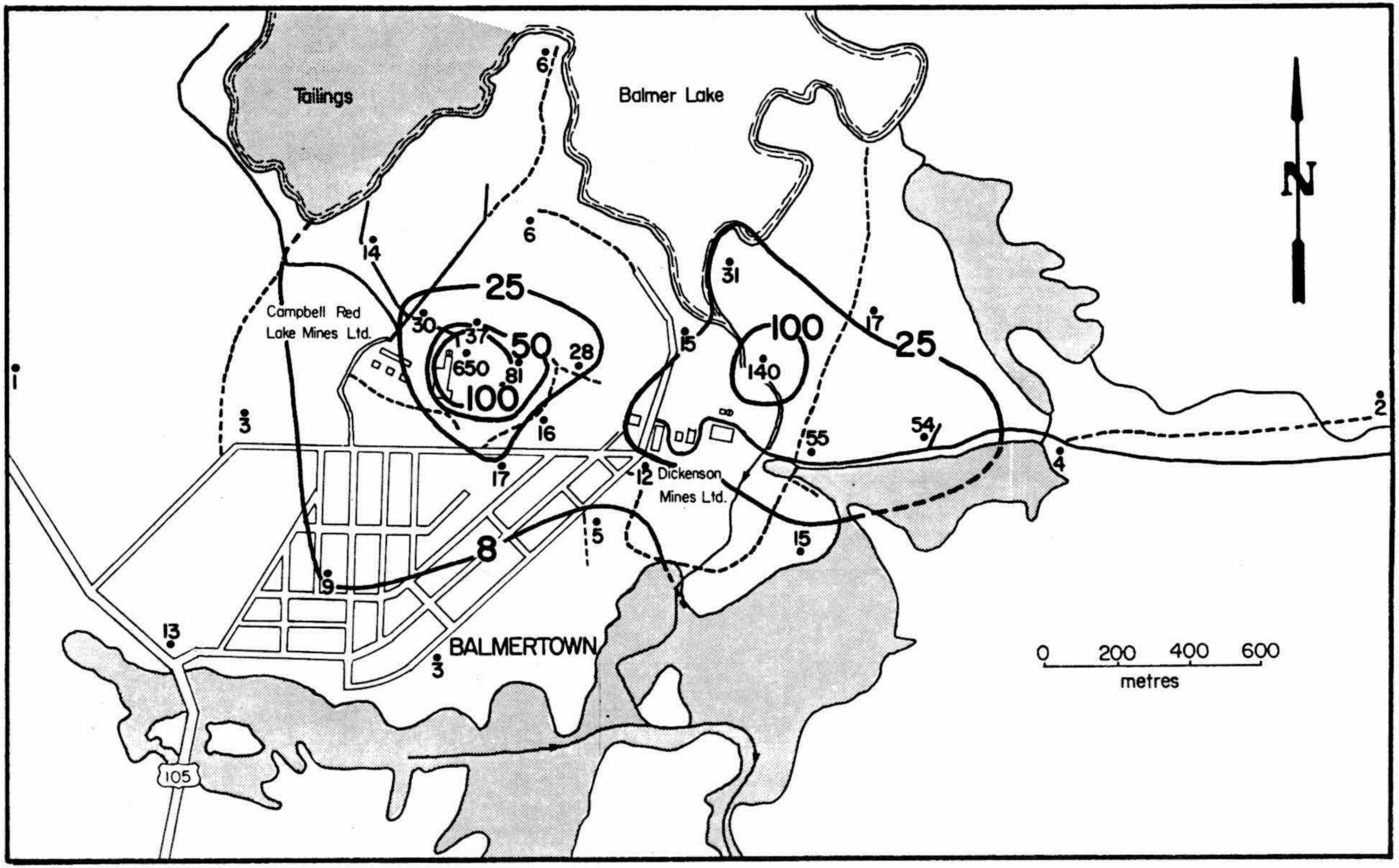



Figure 3. Arsenic ( μg/g, dry weight ) in unwashed trembling aspen foliage, Balmertown, August, 1980.

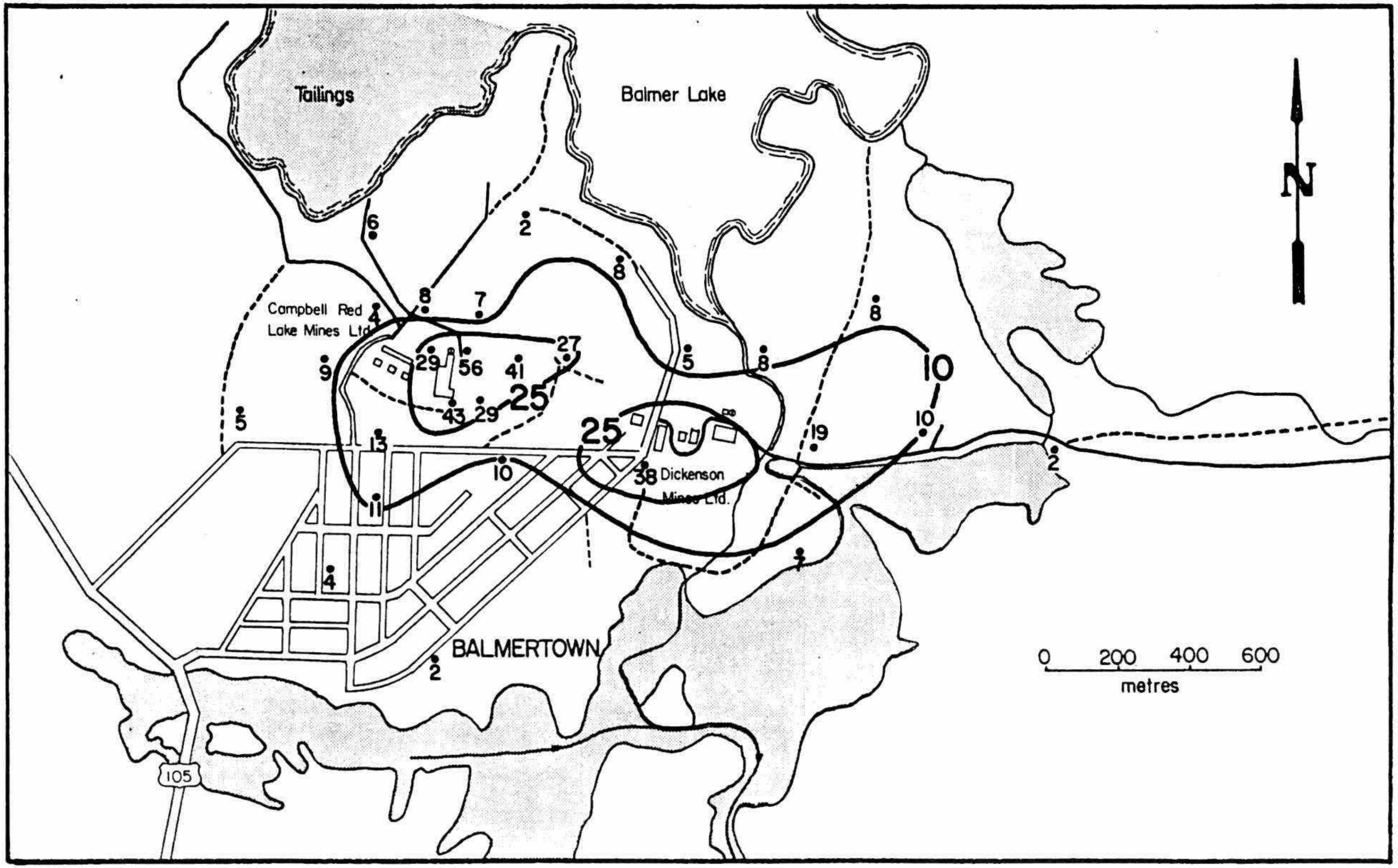



Figure 4. Arsenic ( μg/g , dry weight ) in moss exposed in Balmertown from August 19 to September 30 , 1980.

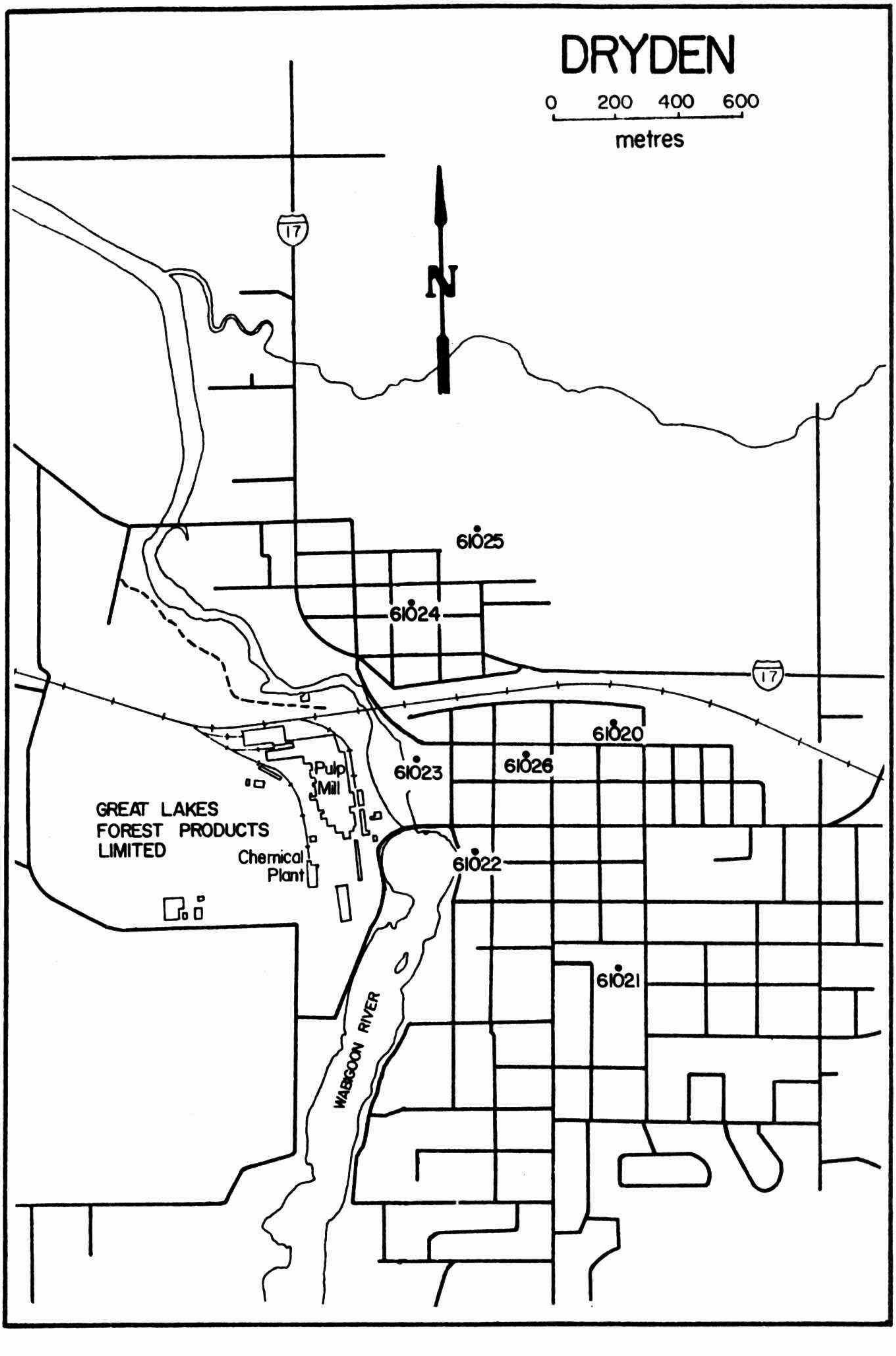
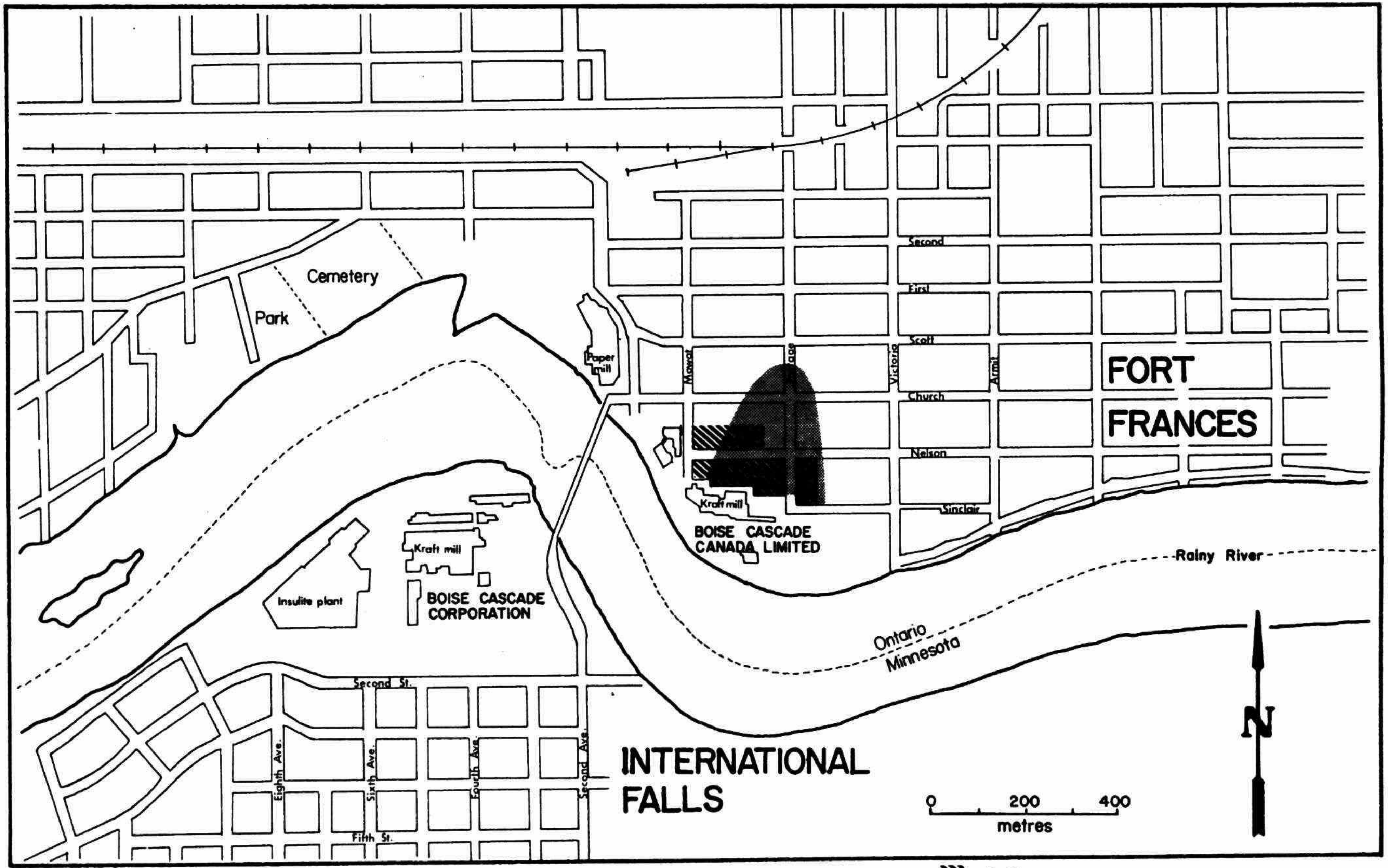



Figure 5. Air quality monitoring sites, Dryden, 1980




Buffer zone

Injury zone

Figure 6. Zone of air pollution injury to Manitoba maple, Fort Frances, 1980.

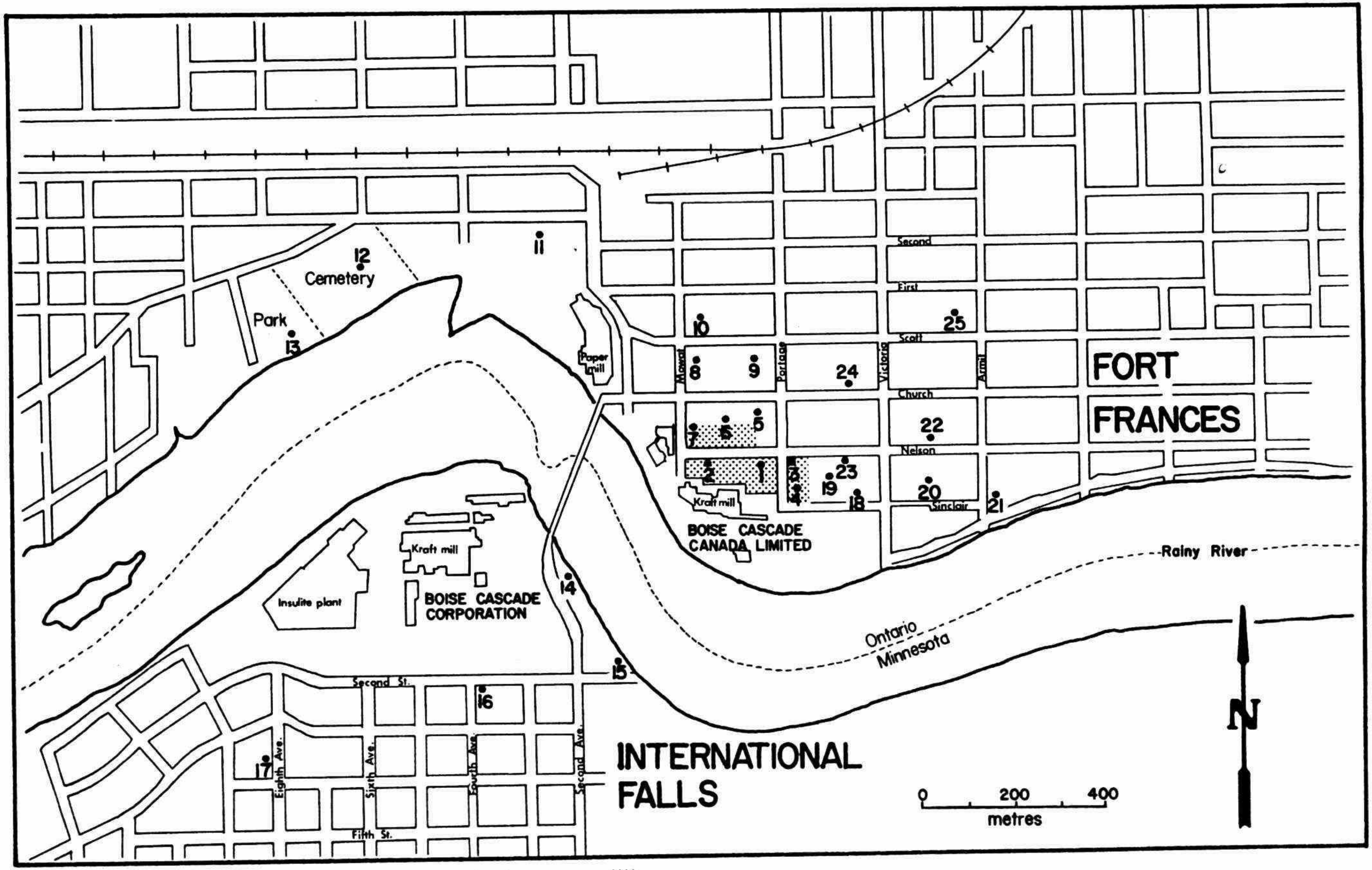



Figure 7. Manitoba maple sampling sites, 1980.

Buffer zone

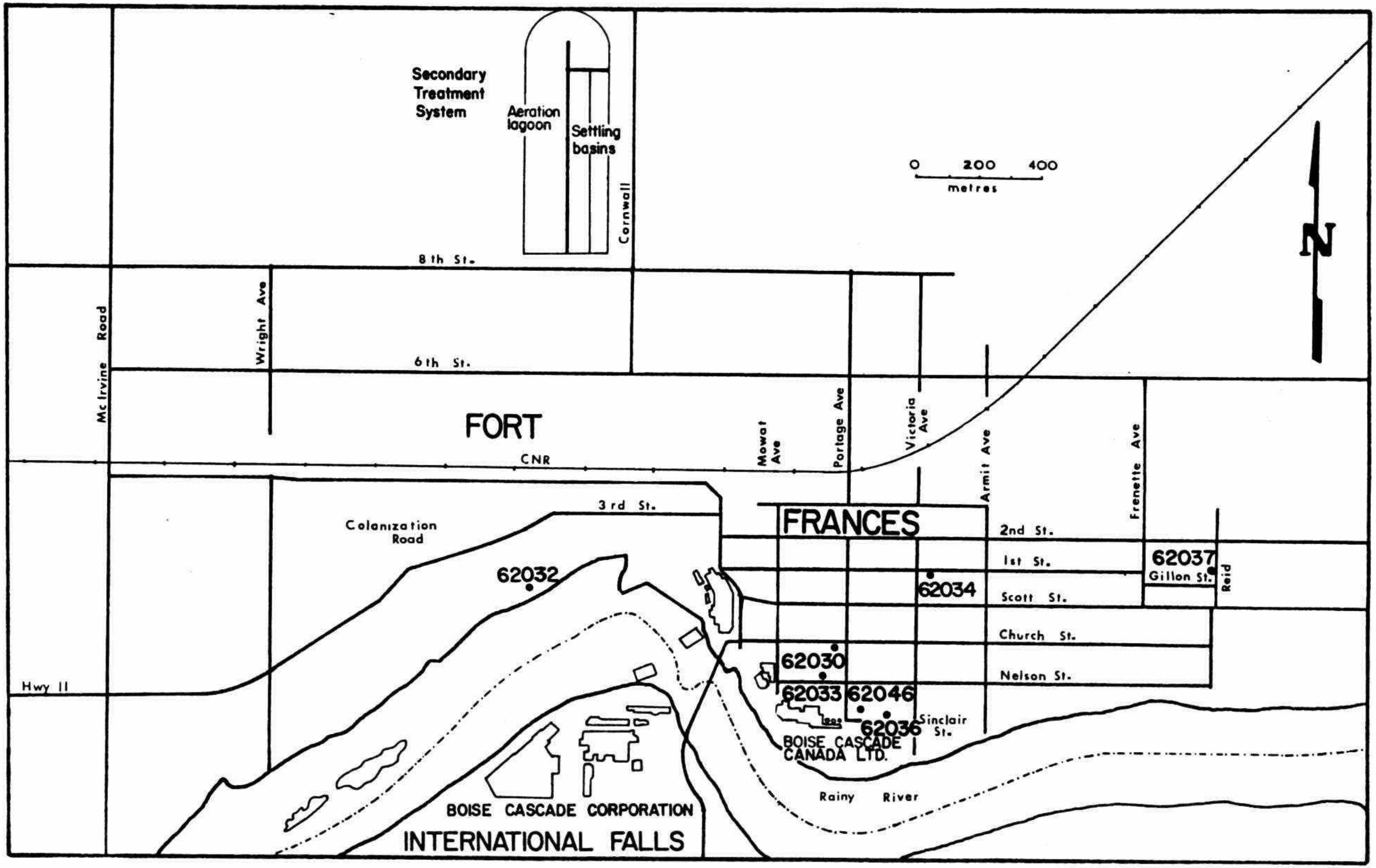



Figure 8. Air quality monitoring sites, Fort Frances, 1980.

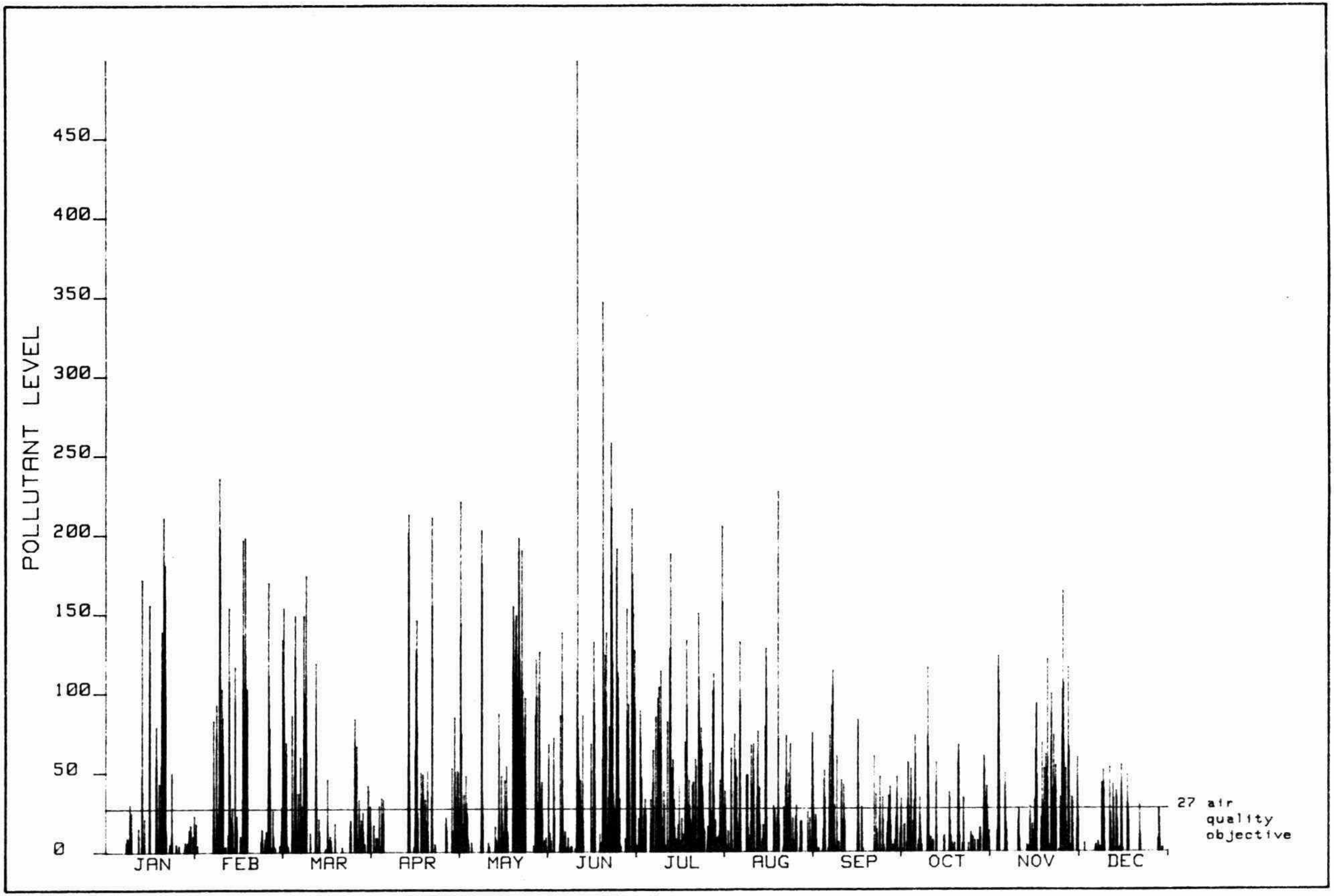



Figure 9 . Hourly average total reduced sulphur concentrations (parts per billion), station 62030, Fort Frances, 1980.

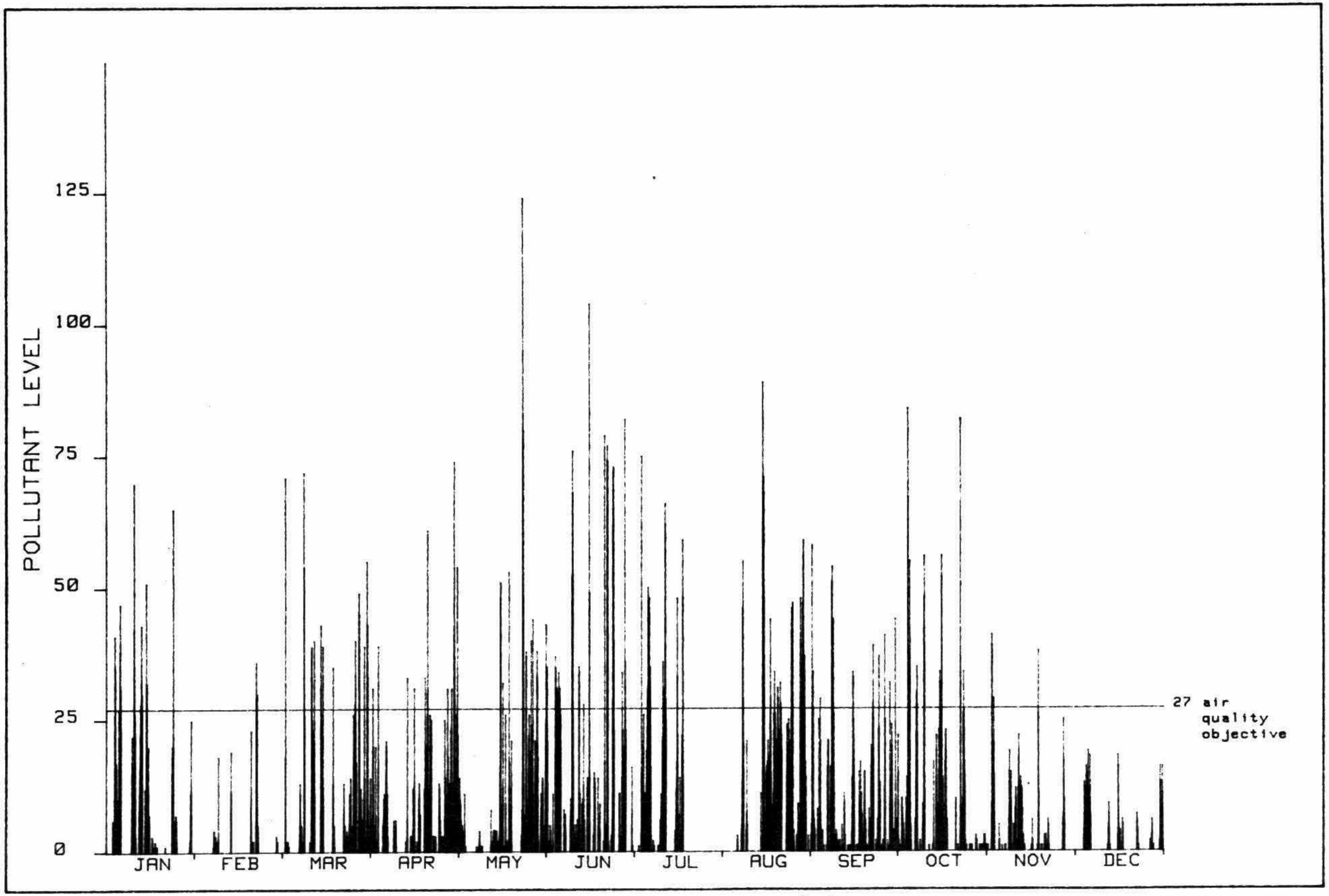



Figure 10. Hourly average total reduced sulphur concentrations (parts per billion), station 62032, Fort Frances, 1980.

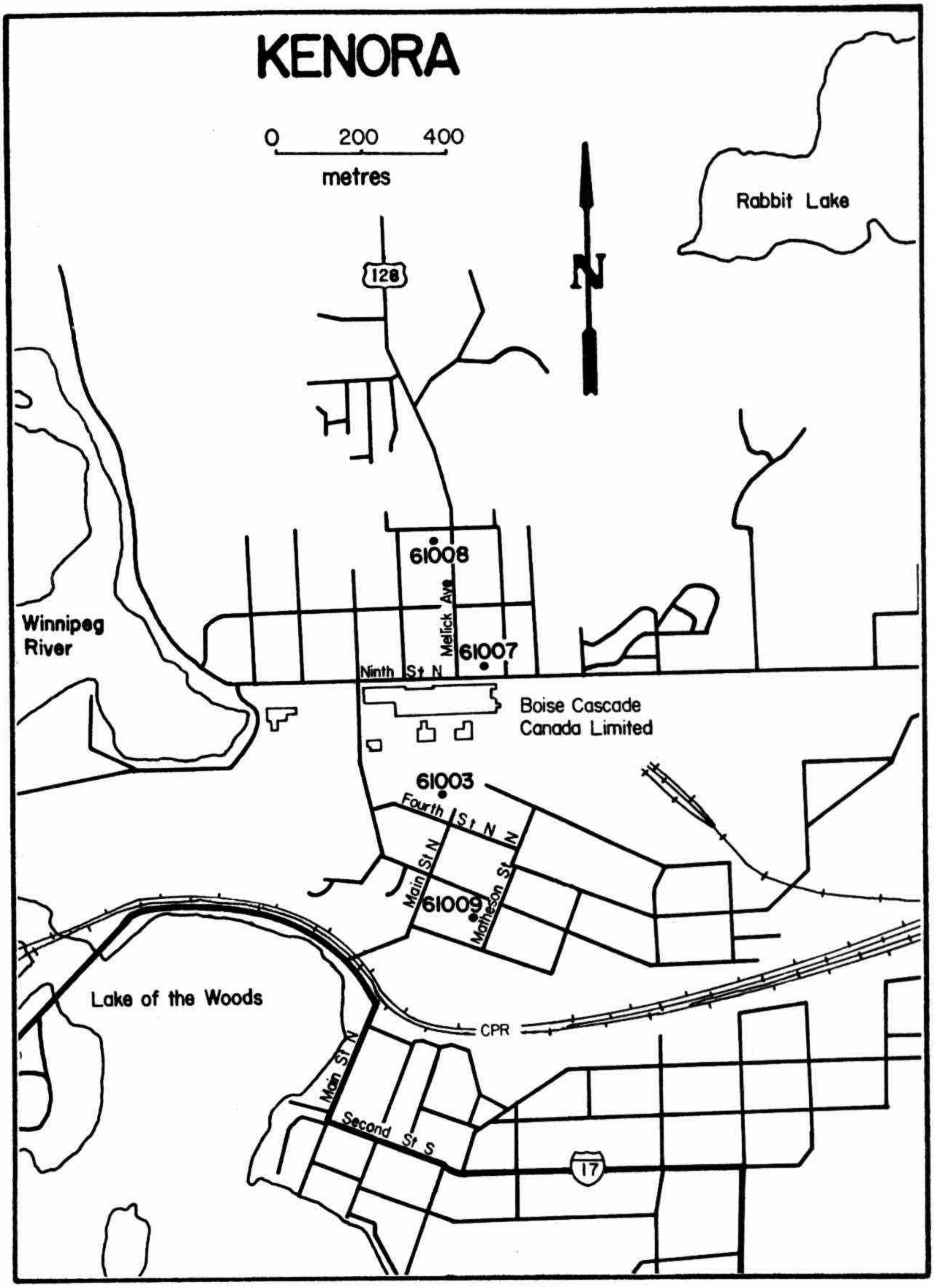



Figure 1?. Air quality monitoring sites, Kenora, 1980.

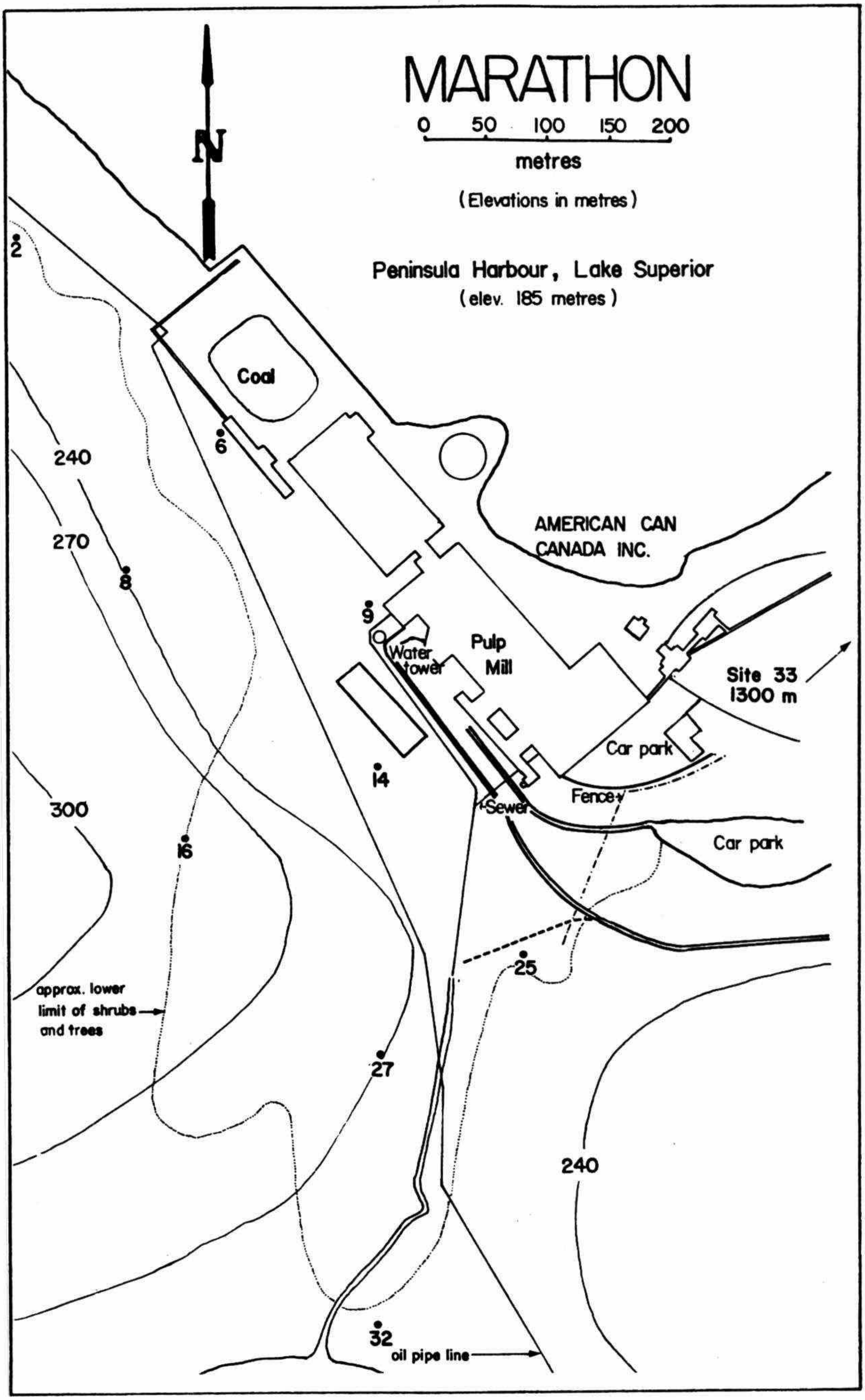



Figure 12. Soil sampling and moss exposure sites, Marathon, 1980.

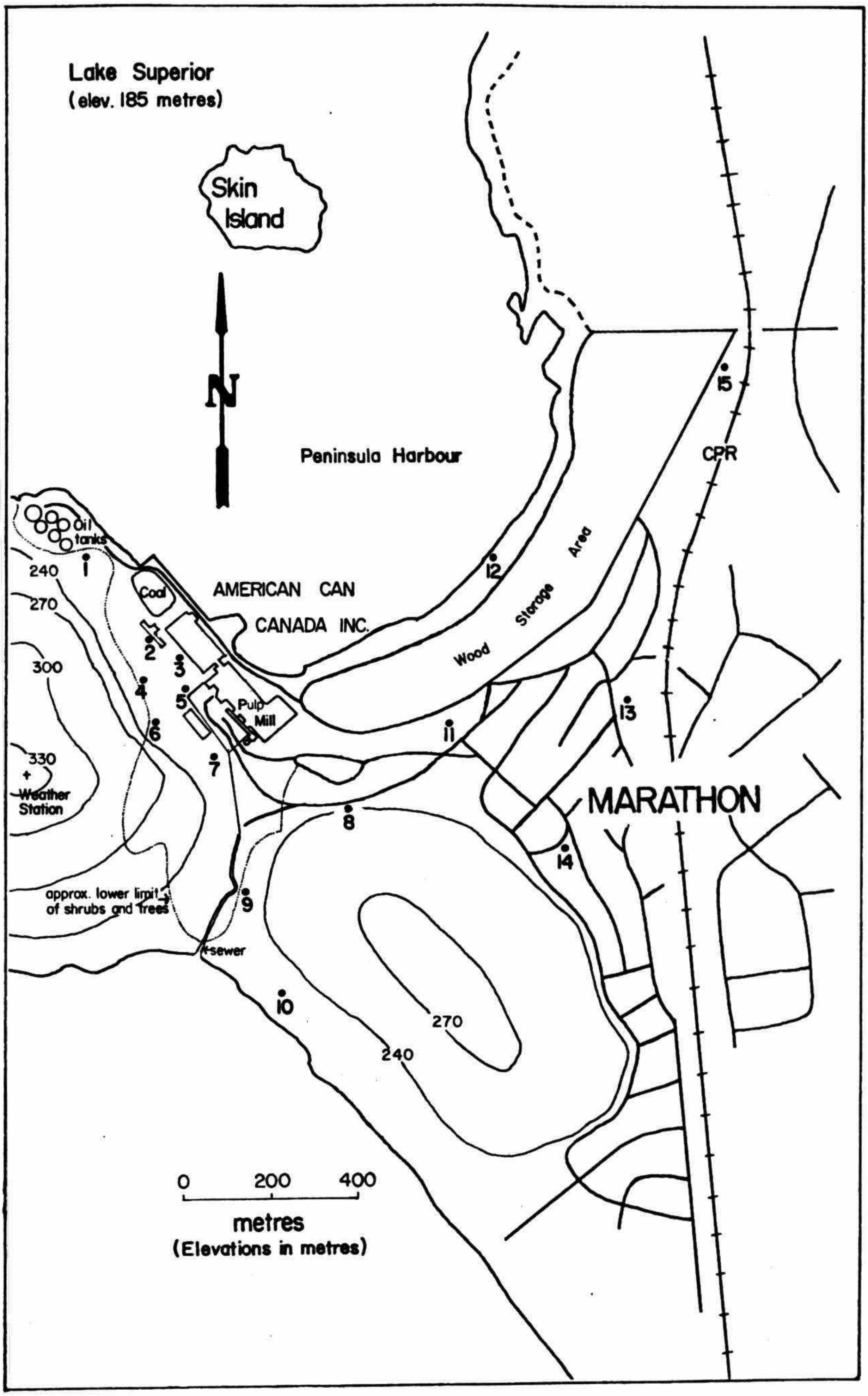



Figure 13. Snow sampling sites, Marathon, 1980.

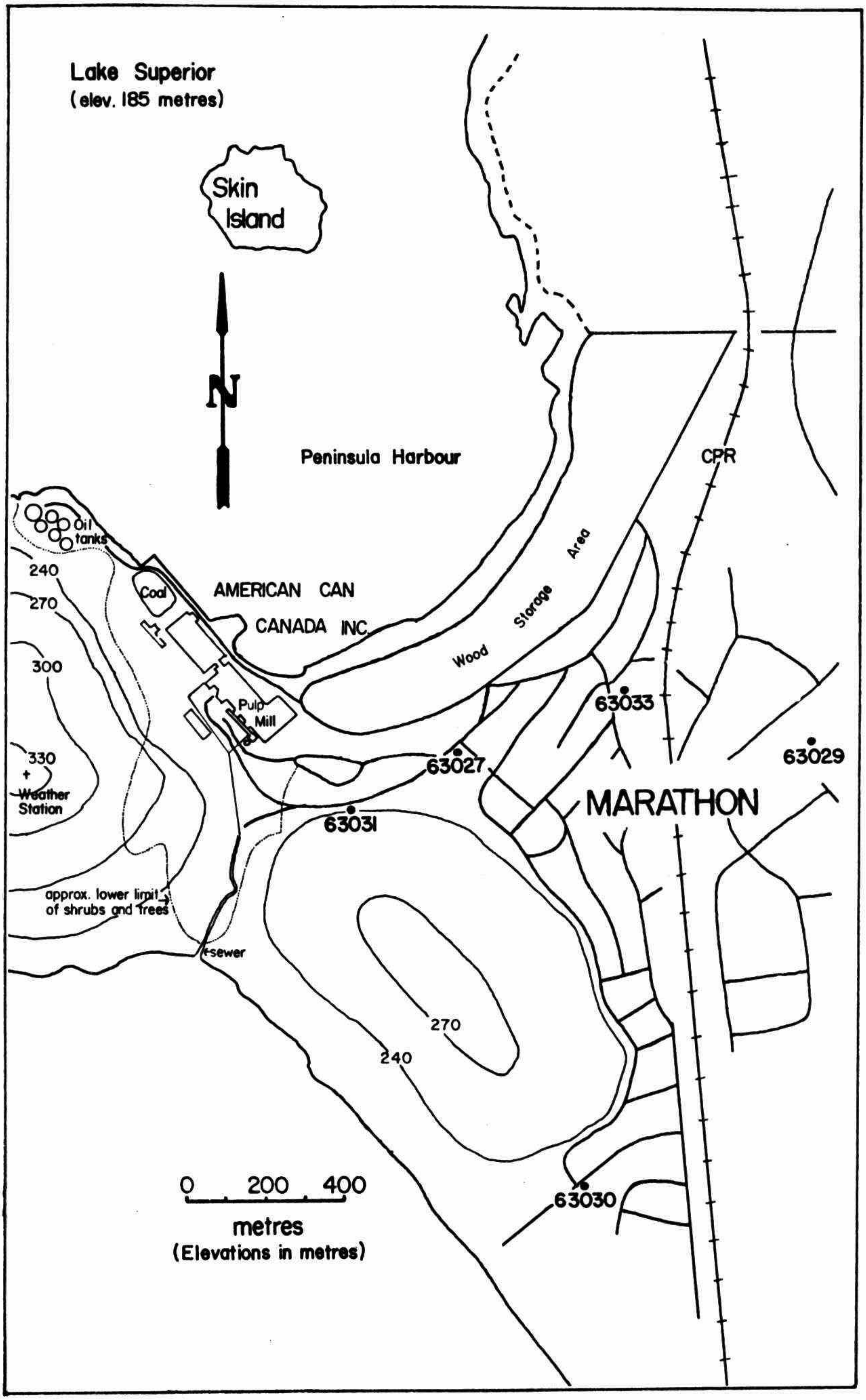



Figure 14. Air quality monitoring sites, 1980 (except station 63032, Heron Bay).

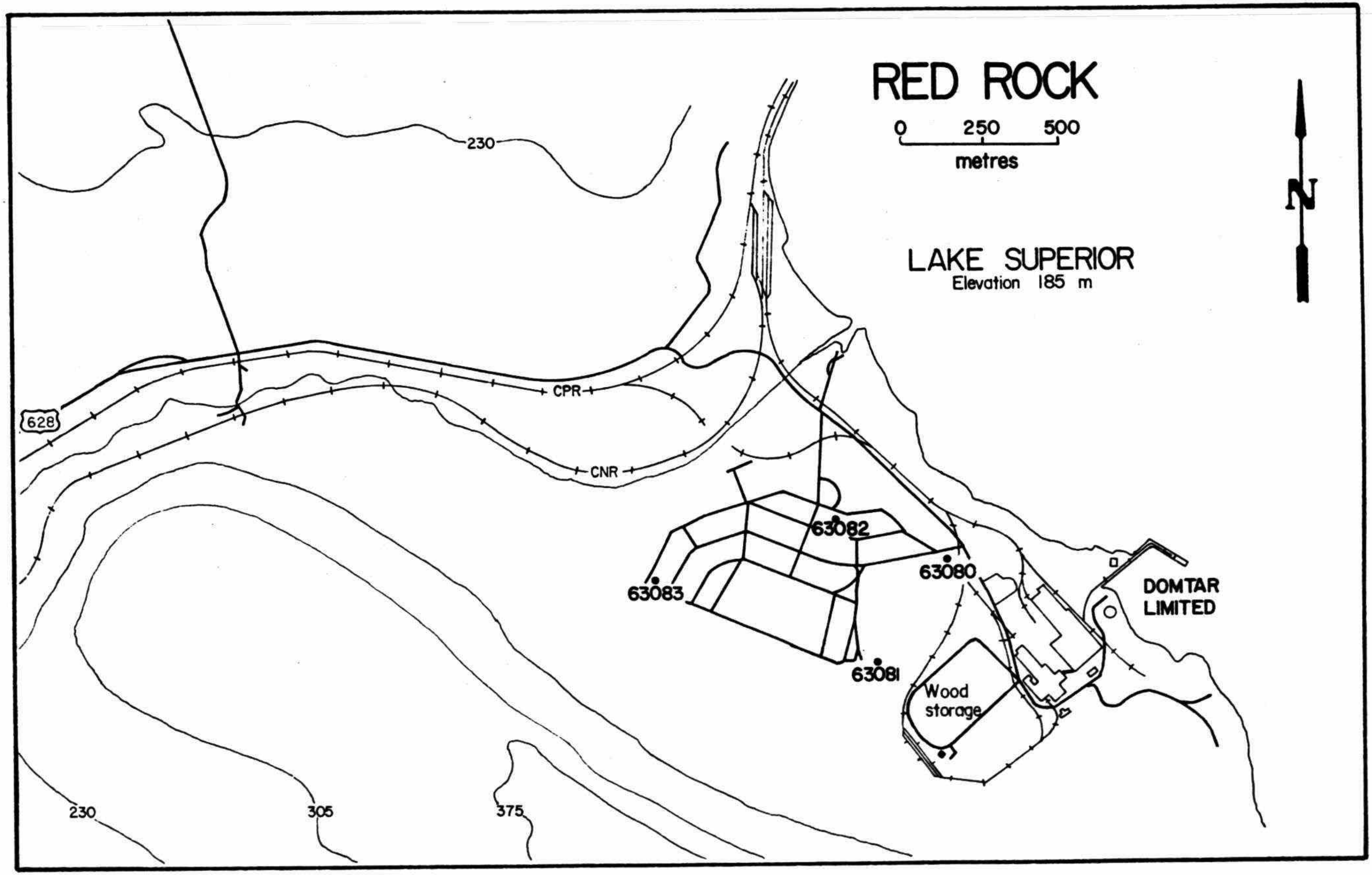



Figure 15. Air quality monitoring sites, Red Rock, 1980.

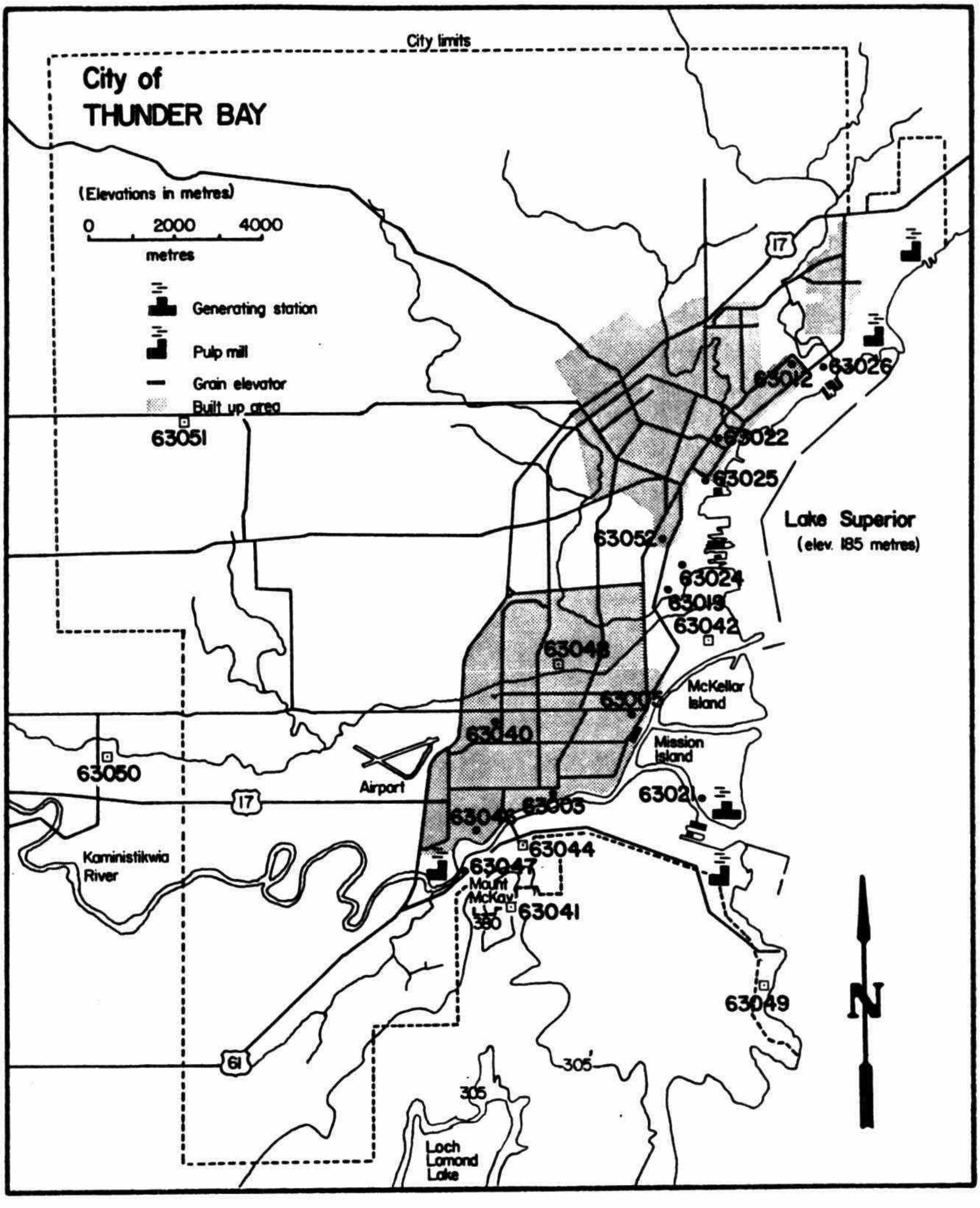



Figure 16. Air quality monitoring sites, Thunder Bay, 1980.
( ◻ Ontario Hydro sites)

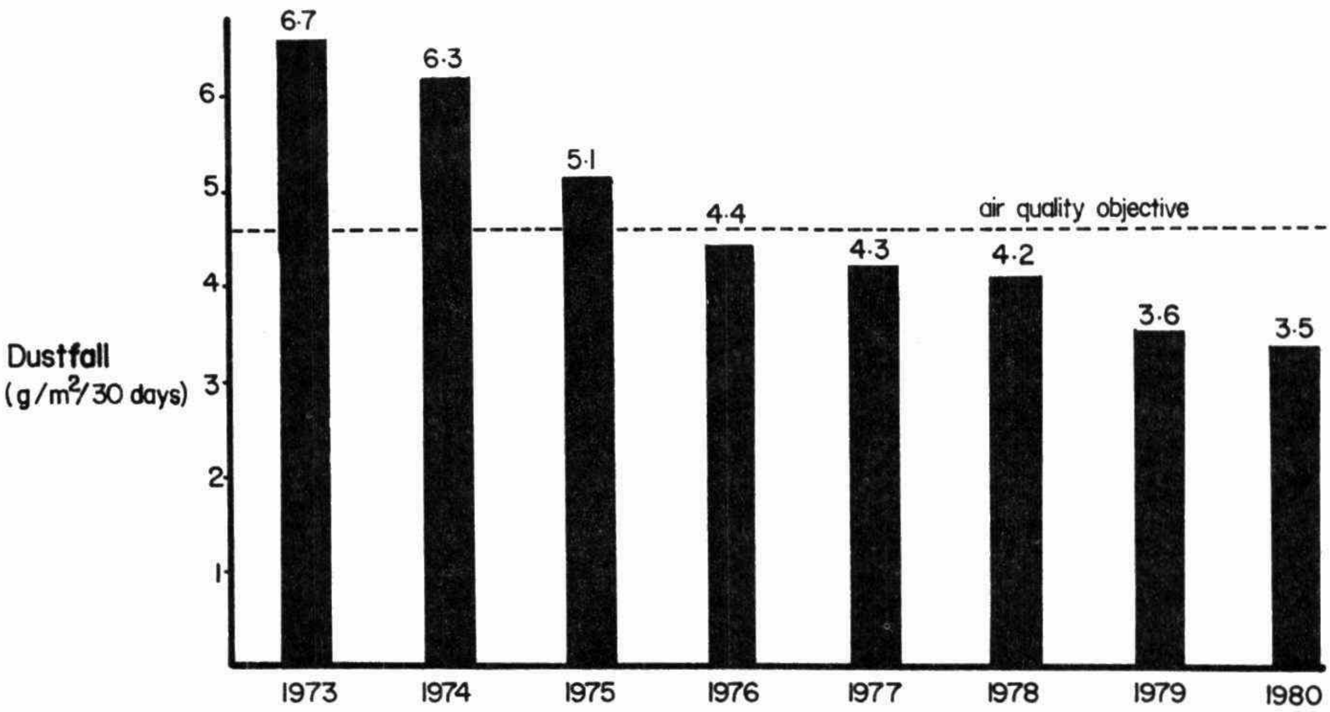



Figure 17. Average annual dustfall, 1973-1980, Thunder Bay.

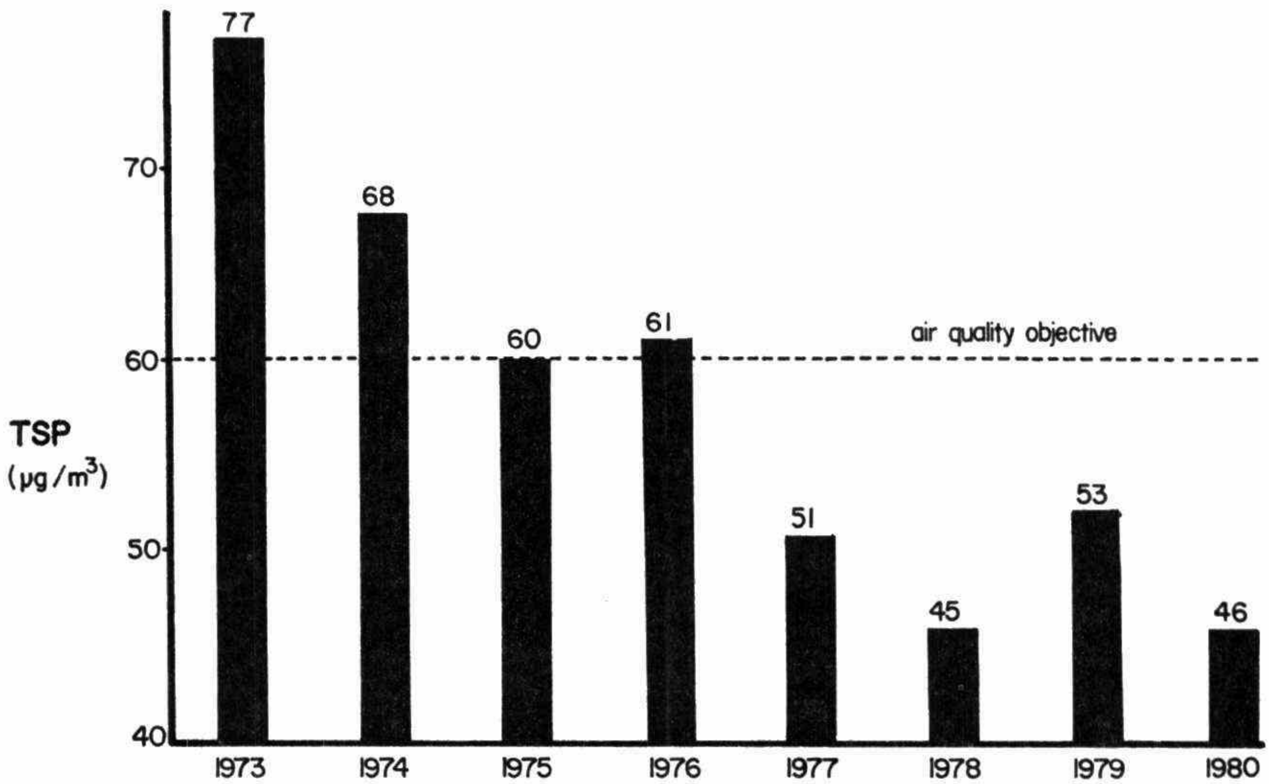



Figure 18. Average total suspended particulate matter ( $\mu g/m^3$ ), 1973-1980, Thunder Bay.

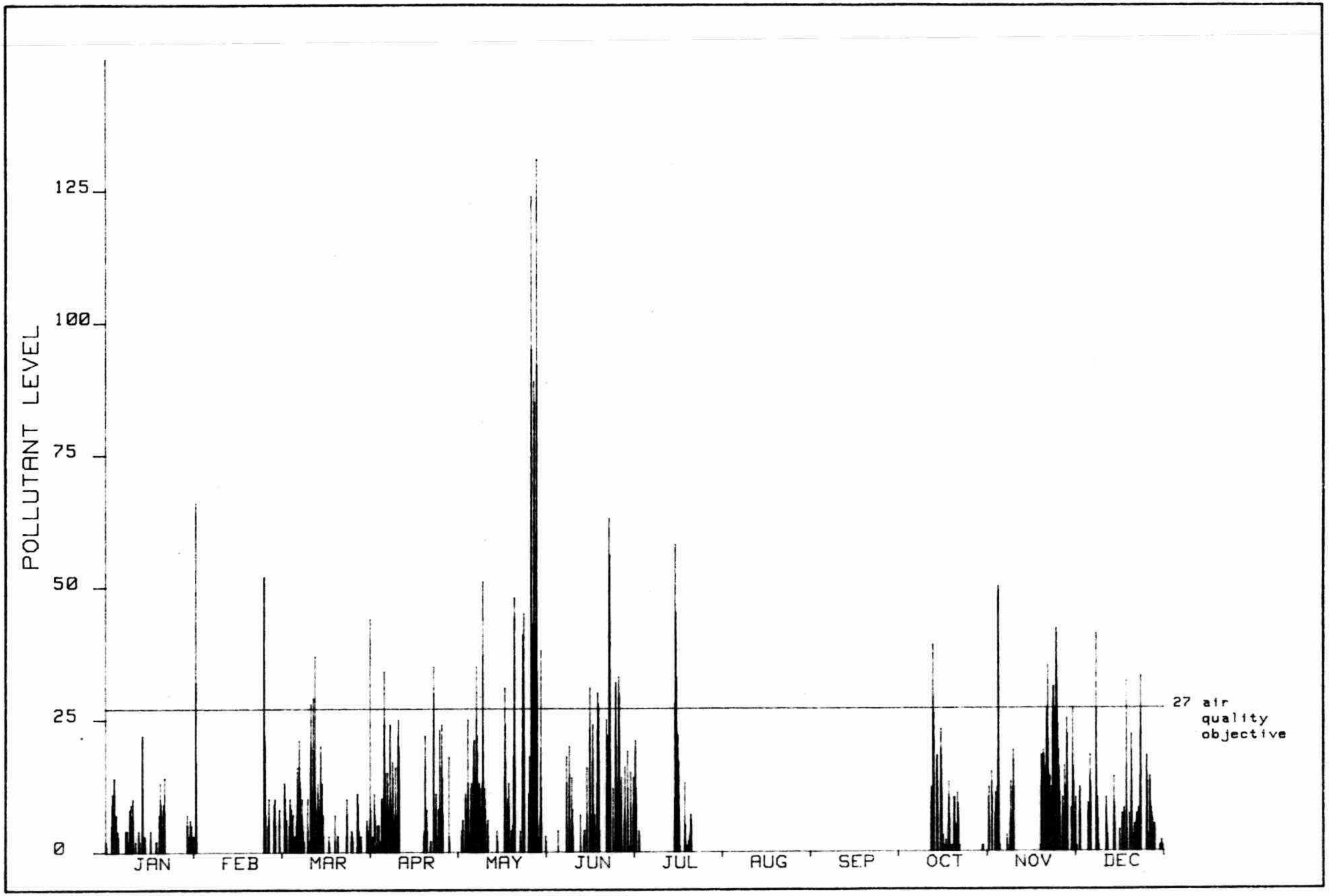



Figure 19. Hourly average total reduced sulphur concentrations (parts per billion), station 63046, Thunder Bay, 1980.

TABLE 1. Comparison between arsenic content (µg/g, dry weight) of unwashed trembling aspen foliage from Balmertown for the period 1972 to 1980.

| Site[a] | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | 26[b] | 31 | 10 | 5 | 4 | 3 | 6 |
| 2 | | | 22 | 26 | 6 | 12 | 9 | 3 | 6 |
| 5 | 160 | 550 | 29 | 33 | 18 | 12 | 9 | 22 | 28 |
| 6 | 78 | 400 | 200 | 260 | 50 | 8 | 33 | 11 | 55 |
| 7 | 21 | 81 | 43 | 29 | 5 | 4 | 20 | 4 | 4 |
| 8 | | | 14 | 18 | 4 | 2 | 6 | 2 | 2 |
| 9 | 260 | 410 | 19 | 6 | 6 | 5 | 5 | 9 | 3 |
| 11 | 98 | 110 | 10 | 7 | 2 | 4 | 2 | 5 | 3 |
| 12 | 27 | 41 | 9 | 9 | 4 | 3 | 3 | 6 | 12 |
| Controls | <1 | 8 | 3 | 2 | <1 | <1 | <1 | <1 | <1 |

[a] Shown in Figure 2.

[b] Values above upper limit of normal background concentration (8 µg/g) are underlined.

TABLE 2. Comparison between average arsenic content (μg/g, dry weight)[a] in unwashed foliage from planted roadside Manitoba maple and white elm trees, Balmertown, 1973 to 1980.

| Year | Side of tree | Dickenson & Mine Road | Balmertown public school | Fifth St. & Mine Road | Controls |
|---|---|---|---|---|---|
| 1973 | Facing | <u>504</u> | <u>734</u>[b] | <u>352</u> | <u>19</u> |
| | Away | <u>323</u> | <u>432</u> | <u>202</u> | <u>25</u> |
| 1974 | Facing | <u>70</u> | <u>36</u> | <u>20</u> | 4 |
| | Away | <u>31</u> | <u>21</u> | <u>12</u> | |
| 1975 | Facing | <u>138</u> | <u>76</u> | <u>34</u> | 4 |
| | Away | <u>58</u> | <u>46</u> | <u>18</u> | |
| 1976 | Facing | <u>18</u> | <u>12</u> | <u>20</u> | 2 |
| | Away | <u>18</u> | <u>9</u> | <u>11</u> | |
| 1977 | Facing | <u>13</u> | 6 | 8 | <1 |
| | Away | <u>16</u> | 5 | 8 | |
| 1978 | Facing | 5 | 5 | 5 | <1 |
| | Away | 4 | 4 | 3 | |
| 1979 | Facing | <u>69</u> | | 8 | 2 |
| | Away | <u>22</u> | | 7 | |
| 1980 | Facing | 7 | 5 | 6 | 1 |
| | Away | 5 | 5 | 3 | |

[a]Values for 1973, 1974, and 1980 represent single samples. Those for other years are averages of triplicate samples.

[b]Values above upper limit of normal background concentration (8 μg/g) are underlined.

TABLE 3. Average arsenic levels[a] (μg/g, dry weight) in washed vegetation and surface soil (0-5 cm) from three[b] Balmertown gardens, 1973-1980.

| Sample | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|
| | Balmertown | | | | | | | |
| Potato - leaves[c] | | 18 | 24 | 15 | 9 | 6 | 37 | 17 |
| - tubers | | 2 | 2 | 2 | <1 | <1 | <1 | 2 |
| Beet - leaves | 180 | 8 | 8 | 7 | 7 | 2 | 13 | 8 |
| - roots | 40 | 3 | 9 | 4 | 6 | 3 | 8 | 6 |
| Lettuce - leaves | 140 | 9 | 18 | 12 | 7 | 9 | 12 | 36 |
| Soil - garden | | 160 | 150 | 60 | 360 | 120 | 93 | 160 |
| - lawn | | 570 | 450 | 210 | 340 | 280 | 270 | 440 |
| | Red Lake (control) | | | | | | | |
| Potato - leaves | | 4 | 2 | 2 | 2 | 1 | 5 | 2 |
| - tubers | | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Beet - leaves | 3 | <1 | <1 | <1 | <1 | <1 | 1 | 2 |
| - roots | 2 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Lettuce - leaves | | 2 | <1 | <1 | <1 | 1 | 1 | 2 |
| Soil - garden | | 10 | 10 | 8 | 7 | 6 | 6 | 7 |
| - lawn | | 14 | 10 | 9 | 8 | 11 | 24 | 11 |

[a]Values for 1973, 1974, and 1975 represent single samples. Those for other years are averages of triplicate samples.

[b]Two gardens in 1979.

[c]Unwashed.

[d]Values above upper limited of normal background levels (8 μg/g for vegetation, 25 μg/g for soil) are underlined.

TABLE 4. Summary of sulphur dioxide concentrations (ppm) in Balmertown, 1977-1980.

| Year | Days of data | Annual average | Maximum 1-hour | Maximum 24-hour | Number of times above objective 1-hour | Number of times above objective 24-hour |
|---|---|---|---|---|---|---|
| 1977 | 108 | 0.011 | 0.56 | 0.22 | 31 | 2 |
| 1978 | 335 | 0.014 | 0.75 | 0.21 | 133 | 9 |
| 1979 | 296 | 0.016 | 0.70 | 0.25 | 153 | 8 |
| 1980 | 247 | 0.011 | 0.70 | 0.18 | 76 | 6 |

TABLE 5. Average annual dustfall ($g/m^2/30$ days), Dryden, 1976 to 1980.

| | Station | | | | | | All stations | |
|---|---|---|---|---|---|---|---|---|
| Year | 61020 | 61021 | 61022 | 61023 | 61024 | 61025 | Total dustfall | Sulphate |
| 1976 | 8.0[a] | 6.3 | 9.8 | 11.5 | 5.9 | 4.5 | 7.7 | 1.6 |
| 1977 | 5.8 | 7.7 | 7.4 | 8.5 | 6.0 | 3.2 | 6.4 | 1.0 |
| 1978 | 4.7 | 5.1 | 6.0 | 4.6 | 2.9 | 2.5 | 4.3 | 0.2 |
| 1979 | 3.9 | 4.7 | 3.2 | 5.3 | 2.8 | 2.7 | 3.8 | 0.3 |
| 1980 | 3.2 | 3.8 | 4.6 | 5.2 | 3.8 | 3.9 | 4.1 | 0.3 |

[a]Values exceeding maximum acceptable limit of 4.6 $g/m^2/30$ days are underlined.

TABLE 6. Average annual sulphation rates (mg $SO_3/100\ cm^2$/day in Dryden, 1976-1980.

| Station | Location | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|
| 61021 | Casimir/St. Charles | | 0.16 | 0.20 | 0.14 | 0.16 |
| 61023 | King/Wabigoon | 0.39 | 0.34 | 0.43 | 0.44 | 0.35 |
| 61025 | Park/Second | | 0.13 | 0.12 | 0.14 | 0.12 |
| 61026 | 56 King Street | | | 0.20 | 0.23 | 0.18 |

TABLE 7. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1977-1980.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| 1977 | 325 | 3.7 | 164 | 270 |
| 1978 | 282 | 6.7 | 479 | 400 |
| 1979 | 200 | 8.7 | 236 | 391 |
| 1980 | 275 | 6.1 | 436 | 476 |

TABLE 8. Average chloride and sodium concentrations in unwashed Manitoba maple foliage[a], Fort Frances-International Falls, 1975-1980.

| Site | Chloride (%, dry weight) | | | | | | Sodium (μg/g, dry weight) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Figure 7) | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| 1 | .26 | .29 | .37 | .33 | .93 | 1.17 | 540 | 770[b] | 2200 | 1100 | 2900 | 1800 |
| 2 | | | | | .77 | .81 | | | | | 1500 | 1400 |
| 3 | | | | | .43 | .87 | | | | | 810 | 1200 |
| 4 | | | | | .21 | .71 | | | | | 530 | 620 |
| 5 | | | | | .25 | .35 | | | | | 700 | 260 |
| 6 | .37 | .16 | .18 | .22 | .29 | .36 | 460 | 1100 | 600 | 400 | 680 | 390 |
| 7 | | | | | .30 | | | | | | 720 | |
| 8 | | | | | .15 | .37 | | | | | 230 | 180 |
| 9 | .33 | .14 | .20 | .19 | .21 | .22 | 400 | 120 | 140 | 170 | 370 | 150 |
| 10 | .08 | .09 | .07 | .14 | .09 | .23 | 320 | 100 | 150 | 120 | 270 | 94 |
| 11 | .08 | .10 | .12 | .07 | .08 | .13 | 350 | 180 | 140 | 67 | 230 | 100 |
| 12 | .07 | .08 | .06 | .08 | .12 | .15 | 560 | 130 | 140 | 53 | 320 | 150 |
| 13 | .04 | .03 | .04 | .02 | .04 | .04 | 1500 | 160 | 100 | 72 | 290 | 83 |
| 14 | .13 | .12 | .05 | .04 | .15 | .08 | 1000 | 140 | 290 | 53 | 140 | 53 |
| 15 | .13 | .17 | .09 | .11 | .22 | .36 | 310 | 220 | 160 | 72 | 310 | 120 |
| 16 | .05 | .08 | .06 | .08 | .14 | .53 | 700 | 150 | 150 | 95 | 260 | 73 |
| 17 | .10 | .07 | .04 | .05 | .07 | .08 | 280 | 100 | 140 | 71 | 390 | 65 |
| 18 | .07 | .13 | .06 | .08 | .13 | .21 | 250 | 170 | 180 | 98 | 240 | 120 |
| 19 | | | | | .11 | .18 | | | | | 190 | 180 |
| 20 | | | | | .10 | .10 | | | | | 240 | 250 |
| 21 | .18 | .14 | .09 | .12 | .24 | .15 | 200 | 120 | 130 | 110 | 400 | 250 |
| 22 | | | | | .13 | .13 | | | | | 330 | 240 |
| 23 | | | | | .16 | .26 | | | | | 140 | 280 |
| 24 | .13 | .12 | .13 | .07 | .13 | .42 | 190 | 150 | 140 | 43 | 180 | 210 |
| 25 | .12 | .16 | .06 | .07 | .15 | .17 | 180 | 180 | 230 | 97 | 280 | 410 |
| controls | .04 | .05 | .06 | .05 | .06 | .10 | 70 | 76 | 52 | 38 | 46 | 100 |

[a]Values are averages for three sets of triplicate samples in 1975, one set of triplicate samples in 1976-1979, and one set of single samples in 1980.

[b]Values above upper limit of normal background concentration (600 μg/g) for sodium in vegetation are underlined.

TABLE 9. Total dustfall ($g/m^2/30$ days), Fort Frances, 1980.

| Station | Location | Distance (metres) and direction from source[a] | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62030 | Church/Portage | 215 NNE | 6.0 | 4.7 | 9.2[b] | 4.0 | 7.6 | 12.2 | 9.9 | 9.0 | 8.0 | 5.6 | 6.2 | 3.0 | 7.1 |
| 62032 | Cemetery | 990 WNW | 2.2 | 0.7 | 2.3 | 3.2 | 4.8 | 4.7 | 3.4 | 4.6 | 4.1 | 2.6 | 2.2 | 1.2 | 3.0 |
| 62033 | Nelson/Portage | 135 NNE | 11.8 | 5.1 | 8.9 | 4.3 | 10.3 | 3.6 | 11.1 | 13.3 | 10.1 | 7.3 | 8.1 | 5.2 | 8.2 |
| 62034 | First/Victoria | 590 NE | 3.4 | 2.5 | 5.5 | 9.4 | 5.8 | 4.8 | 7.0 | 6.9 | 7.3 | 4.2 | 3.3 | 2.1 | 5.2 |
| 62036 | Sinclair/Victoria | 295 E | 7.8 | 2.1 | 5.9 | 6.3 | 9.1 | 14.2 | 23.3 | 19.4 | 13.5 | 11.6 | 7.3 | 6.3 | 10.6 |
| 62037 | Reid/Gillon | 1385 E | 0.8 | 1.3 | 18.7 | 1.6 | 4.0 | 7.1 | 4.4 | 5.9 | 8.2 | 10.4 | 2.0 | 1.3 | 5.5 |
| 62046 | Sinclair/Portage | 150 E | 11.8 | 11.6 | 8.2 | 4.2 | 7.0 | 11.7 | 13.2 | 12.7 | 8.0 | 9.4 | 10.3 | 8.5 | 9.7 |

[a]Source arbitrarily designated as Boise Cascade Canada Limited kraft mill recovery furnace stack.

[b]Underlined values exceed maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average).

TABLE 10. Saltcake ($Na_2SO_4$) ($g/m^2$/30 days), Fort Frances, 1980.

| Station | Location | Distance (metres) and direction from source[a] | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62030 | Church/Portage | 215 NNE | 4.2 | 1.4 | 1.1 | 0.2 | 1.6 | 0.8 | 1.3 | 2.9 | 1.0 | 1.1 | 1.6 | 0.7 | 1.5 |
| 62032 | Cemetery | 990 WNW | 1.8 | 0.3 | 0.3 | 0.1 | 0.3 | 0.3 | 0.3 | 1.2 | 0.6 | 0.5 | 0.5 | 0.5 | 0.6 |
| 62033 | Nelson/Portage | 135 NNE | 11.2 | 2.6 | 1.2 | 0.5 | 2.9 | 0.2 | 2.6 | 6.2 | 1.8 | 3.1 | 3.1 | 1.1 | 3.0 |
| 62034 | First/Victoria | 590 NE | 2.3 | 0.8 | 1.7 | 0.3 | 0.6 | 0.1 | 0.8 | 1.9 | 0.7 | 0.8 | 0.6 | 0.6 | 1.0 |
| 62036 | Sinclair/Victoria | 295 E | 4.9 | 0.4 | 1.1 | 0.7 | 1.2 | 1.2 | 1.2 | 1.9 | 1.7 | 2.7 | 2.0 | 1.4 | 1.7 |
| 62037 | Reid/Gillon | 1385 E | 1.0 | 0.5 | 1.1 | 0.2 | 0.4 | 0.7 | 0.4 | 1.2 | 1.1 | 1.2 | 0.5 | 0.4 | 0.7 |
| 62046 | Sinclair/Portage | 150 E | 6.1 | 1.3 | 1.2 | 1.0 | 1.2 | 1.6 | 1.3 | 2.0 | 1.2 | 3.1 | 1.8 | 1.4 | 1.9 |

[a]Source arbitrarily designated as Boise Cascade Canada Limited kraft mill recovery furnace stack.

TABLE 11. Average annual sulphation rates (mg $SO_3$/100 $cm^2$/ day), Fort Frances, 1977-1980.

| Station | Location | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|
| 62030 | Church/Portage | 0.24 | 0.26 | 0.20 | 0.14 |
| 62032 | Cemetery | 0.18 | 0.14 | 0.13 | 0.09 |
| 62033 | Nelson/Portage | 0.49 | 0.51 | 0.40 | 0.27 |
| 62034 | First/Victoria | 0.14 | 0.15 | 0.13 | 0.09 |
| 62036 | Sinclair/Victoria | 0.24 | 0.19 | 0.13 | 0.09 |
| 62037 | Reid/Gillon | 0.09 | 0.11 | 0.09 | 0.09 |
| | Averages | 0.23 | 0.23 | 0.18 | 0.13 |

TABLE 12. Summary of total reduced sulphur concentrations (ppb), stations 62030 and 62032, Fort Frances, 1976-1980.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| | | | Station 62030 | |
| 1976 | 309 | 12.8 | 458 | 916 |
| 1977 | 294 | 15.4 | 480 | 969 |
| 1978 | 304 | 16.1 | 540 | 1035 |
| 1979 | 344 | 10.2 | 353 | 911 |
| 1980 | 352 | 9.3 | 499 | 872 |
| | | | Station 62032 | |
| 1976 | 139 | 2.5 | 116 | 91 |
| 1977 | 225 | 3.3 | 129 | 176 |
| 1978 | 281 | 2.5 | 134 | 141 |
| 1979 | 306 | 2.9 | 140 | 178 |
| 1980 | 307 | 3.3 | 124 | 210 |

TABLE 13. Average hourly concentrations (ppb) of total reduced sulphur for different wind directions, Fort Frances, 1978-1980.

| Wind direction[a] | Station 62030 | | | Station 62032 | | |
|---|---|---|---|---|---|---|
| | 1978 | 1979 | 1980 | 1978 | 1979 | 1980 |
| 350-20 | 1 | <1 | 2 | 2 | 3 | 3 |
| 30-60 | <1 | <1 | 1 | <1 | 2 | 2 |
| 70-100 | 1 | <1 | 0 | 3 | 3 | 3 |
| 110-140 | 2 | 1 | 2 | 9 | 10 | 9 |
| 150-180 | 24 | 20 | 12 | 6 | 8 | 10 |
| 190-220 | 75 | 51 | 48 | 1 | <1 | 1 |
| 230-260 | 28 | 17 | 18 | <1 | 0 | 0 |
| 270-300 | 5 | 2 | 2 | 0 | 0 | 0 |
| 310-340 | 3 | 3 | 2 | 1 | <1 | <1 |
| Calm | 17 | 16 | 13 | 4 | 3 | 5 |

[a]Degrees, 6.4 m above ground, International Falls airport, Minnesota.

TABLE 14. Average annual dustfall ($g/m^2/30$ days), Kenora, 1974-1980.

| Station | Location | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|
| 61003 | Fourth/Main | $\underline{6.3}$[a] | $\underline{5.6}$ | 4.2 | $\underline{5.7}$ | $\underline{9.5}$ | 4.6 | 4.1 |
| 61006 | Matheson/Fourth | $\underline{5.2}$ | 4.2 | 3.5 | 4.4 | $\underline{4.9}$ | | |
| 61007 | Melick/Ninth | $\underline{14.4}$ | $\underline{7.7}$ | $\underline{7.7}$ | $\underline{11.9}$ | $\underline{14.7}$ | $\underline{8.6}$ | $\underline{10.7}$ |
| 61008 | Melick/Eleventh | $\underline{6.3}$ | $\underline{6.0}$ | $\underline{6.0}$ | 3.7 | $\underline{5.3}$ | 3.8 | 3.7 |
| 61009 | Third/Matheson | | | | | | | $\underline{5.6}$ |

[a]Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 15. Comparison between mercury levels (μg/g, dry weight) in soil sampled in 1976, 1978, 1979, and 1980 near the American Can chlor-alkali plant, Marathon.

| Sampling site[a] | Soil depth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0-5 cm | | | | 5-10 cm | | | 10-15 cm | | |
| | 1976 | 1978 | 1979 | 1980 | 1976 | 1978 | 1980 | 1976 | 1978 | 1980 |
| 2 | 4 | 5 | 2 | 3 | 3 | 2 | 3 | 3 | | 2 |
| 6 | 14 | 18 | 18 | 4 | 11 | 2 | <1 | 6 | <1 | <1 |
| 8 | 3 | 5 | 4 | 4 | 5 | <1 | 8 | <1 | | 7 |
| 9 | 36 | 58 | 40 | 45 | 32 | 13 | 10 | 21 | 3 | 2 |
| 14 | 18 | 12 | 3 | 5 | 14 | 4 | 1 | 13 | 2 | <1 |
| 16 | 3 | 3 | 3 | 3 | 2 | <1 | <1 | <1 | <1 | <1 |
| 25 | 2 | 2 | <1 | 2 | 1 | <1 | <1 | <1 | <1 | <1 |
| 27 | 1 | 1 | 4 | 3 | <1 | <1 | 2 | <1 | | <1 |
| 32 | 48 | 43 | 32 | 21 | 22 | 16 | 4 | 6 | 4 | 2 |
| 33 | 12 | 7 | 8 | 15 | | | 2 | | | <1 |
| Average | 14 | 15 | 11 | 10 | 10 | 4 | 3 | 6 | | 2 |
| controls | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| normal background | <0.3 | | | | <0.3 | | | <0.3 | | |

[a]See Figure 11.

TABLE 16. Comparison between average levels (mg/l) of chloride, sodium, and sulphate in meltwater from snow sampled in 1978 and 1980 at Marathon.

| Sampling site | Chloride | | Sodium | | Sulphate | |
|---|---|---|---|---|---|---|
| | 1978 | 1980 | 1978 | 1980 | 1978 | 1980 |
| 1 | 8[a] | 1 | 9 | 2 | 11 | 3 |
| 2 | 22 | 1 | 33 | 2 | 52 | 4 |
| 3 | 22 | 4 | 62 | 3 | 82 | 6 |
| 4 | 12 | 1 | 54 | 2 | 94 | 6 |
| 5 | 29 | 4 | 120 | 6 | 140 | 14 |
| 6 | 13 | 2 | 56 | 4 | 100 | 10 |
| 7 | 140 | 9 | 120 | 89 | 200 | 100 |
| 8 | 2 | 1 | 26 | 3 | 63 | 6 |
| 9 | 10 | 2 | 28 | 6 | 65 | 8 |
| 10 | 2 | 1 | 12 | 1 | 30 | 2 |
| 11 | 2 | 9 | 11 | 6 | 18 | 2 |
| 12 | 1 | 2 | 2 | 1 | 4 | <1 |
| 13 | 4 | 2 | 3 | 2 | 5 | 1 |
| 14 | 1 | 3 | 4 | 3 | 8 | 1 |
| 15 | 1 | 3 | 2 | 2 | 2 | 1 |
| controls | <1 | <1 | <1 | <1 | 1 | <1 |

[a]Values above upper limit of normal background concentration (5 mg/l for all three contaminants) are underlined.

TABLE 17. Comparison between mercury concentrations (μg/g, dry weight) in *Sphagnum* moss exposed during the summers of 1976 to 1980 at Marathon.

| Sampling sites (Figure 12) | Year and exposure period (days) 1976 (30) | 1977 (51) | 1978 (36) | 1979 (40) | 1980 (36) |
|---|---|---|---|---|---|
| 2 | 0.6 | 1.0 | | 0.2 | <0.1 |
| 6 | 2.4 | 3.5 | 0.4 | 0.4 | 0.3 |
| 8 | 1.1 | 0.8 | 0.1 | 0.2 | 0.1 |
| 9 | 48.0 | 180.0 | 5.4 | 2.7 | 1.3 |
| 14 | 6.8 | 8.9 | 0.5 | 0.1 | 0.2 |
| 16 | 0.6 | 0.2 | 0.4 | 0.2 | <0.1 |
| 25 | 0.2 | 0.5 | 0.1 | 0.1 | <0.1 |
| 27 | | | 0.2 | 0.2 | 0.2 |
| 32 | 0.2 | 0.3 | 0.1 | 0.2 | 0.1 |
| 33 | | | | 0.2 | 0.3 |
| exposed controls | <0.1 | <0.1 | 0.1 | 0.2 | <0.1 |
| unexposed controls | | <0.1 | 0.1 | 0.1 | <0.1 |

TABLE 18. Average annual dustfall ($g/m^2/30$ days), Marathon, 1975-1980.

| | Monitoring sites | | | |
|---|---|---|---|---|
| | 63027 | 63029 | 63030 | 63033 |
| Year | McLeod/Abrams | Marathon Shell | Howe/Yawkey | Water Tower |
| 1975 | 4.6 | 3.2 | 3.9 | |
| 1976 | 4.9[a] | 3.5 | 3.9 | |
| 1977 | 7.4 | 7.0 | 5.8 | |
| 1978 | 6.0 | 7.3 | 4.2 | |
| 1979 | 5.2 | 4.4 | 2.4 | 2.9 |
| 1980 | 4.5 | 5.2 | 2.4 | 2.8 |

[a]Values above maximum acceptable limit of 4.6 are underlined.

TABLE 19. Average annual sulphation rates (mg $SO_3/100\ cm^2$/day), Marathon, 1976 to 1980.

| Station | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|
| 63027 | .22 | .27 | .37 | .15 | .12 |
| 63029 | .15 | .17 | .20 | .17 | .09 |
| 63030 | .18 | .23 | .23 | .15 | .11 |
| 63031 | .46 | .56 | .71 | .19 | .20 |
| 63032 | | | .10 | .10 | .06 |
| 63033 | | | | .16 | .16 |

TABLE 20. Dustfall ($g/m^2$/30 days), Red Rock, 1980.

| Station | Location | Distance (metres) and direction from source[a] | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total dustfall | | | | | | | | | | | | |
| 63080 | Rankin Street | 550 NW | 7.0 | 3.4 | 10.4[b] | 7.1 | 6.1 | 9.0 | 9.9 | 17.2 | 15.0 | 10.4 | 8.2 | 6.4 | 9.2 |
| 63081 | Stewart/Frost | 550 W | 5.1 | 5.2 | 4.1 | 5.2 | 7.6 | 5.5 | 16.6 | 16.5 | 7.0 | 3.2 | 6.6 | 6.4 | 7.4 |
| 63082 | 47 Timmins Street | 875 NW | 11.4 | 3.5 | 6.8 | 8.9 | 12.7 | 20.6 | 18.8 | 19.8 | 18.4 | | 8.1 | 8.1 | 12.5 |
| 63083 | 122 Brompton Road | 1300 WNW | 2.9 | 3.6 | 4.2 | 3.1 | 4.4 | 3.5 | 6.9 | 6.1 | 4.4 | 3.2 | 1.6 | 2.2 | 3.8 |
| | | | Saltcake ($Na_2SO_4$) in dustfall | | | | | | | | | | | | |
| 63080 | Rankin Street | 550 NW | 4.1 | 0.7 | 2.9 | 2.0 | - | 3.1 | 2.6 | 4.4 | 4.8 | 3.2 | 3.5 | 3.3 | 3.1 |
| 63081 | Stewart/Frost | 550 W | 3.1 | 1.7 | 1.3 | 0.8 | - | 1.1 | 2.0 | 3.1 | 2.5 | 1.2 | 2.6 | 4.4 | 2.2 |
| 63082 | 47 Timmins Street | 875 NW | 9.1 | 0.7 | 2.7 | 4.2 | - | 11.6 | 12.2 | 11.0 | 11.1 | 6.0 | 5.7 | 6.6 | 7.4 |
| 63083 | 122 Brompton Road | 1300 WNW | 3.3 | 1.2 | 1.3 | 0.7 | - | 0.8 | 1.1 | 1.9 | 1.3 | 1.3 | 1.2 | 1.6 | 1.4 |

[a]Source arbitrarily designated as recovery furnace stacks, Domtar kraft pulp mill.

[b]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 21. Average sulphation rates (mg $SO_3$/100 $cm^2$/day) in Red Rock, 1978-1980.

| Station | 1978[a] Range | 1978[a] Mean | 1979 Range | 1979 Mean | 1980 Range | 1980 Mean |
|---|---|---|---|---|---|---|
| 63080 | 0.11-1.33 | 0.96 | 0.02-1.10 | 0.58 | 0.09-1.03 | 0.66 |
| 63081 | 0.07-0.44 | 0.19 | 0.03-0.23 | 0.13 | 0.03-0.34 | 0.15 |
| 63082 | 0.06-0.83 | 0.34 | 0.02-0.48 | 0.24 | 0.02-0.66 | 0.27 |
| 63083 | 0.01-0.17 | 0.11 | 0.01-0.18 | 0.09 | 0.03-0.31 | 0.13 |

[a]9 months of data.

TABLE 22. Total dustfall (g/$m^2$/30 days) and average pH of dustfall solutions, Thunder Bay, 1980.

| Station | Location | Dustfall Min | Dustfall Max | Dustfall Mean | pH |
|---|---|---|---|---|---|
| 63003 | 185 Gore Street | 1.3 | 7.1[a] | 4.0 | 5.1 |
| 63005 | McKellar Hospital | 1.0 | 6.9 | 4.0 | 4.3 |
| 63012 | Dawson Court | 0.5 | 6.0 | 2.8 | 4.3 |
| 63019 | Main St. Pumping Station | 0.8 | 7.4 | 3.4 | 4.4 |
| 63021 | Mission Island | 0.6 | 4.6 | 2.5 | 3.5 |
| 63022 | St. Joseph's Hospital | 0.4 | 5.5 | 3.4 | 4.2 |
| 63024 | Hammond Avenue/Inter-City | 0.8 | 8.4 | 4.4 | 4.7 |
| 63025 | Manitou Street | 0.5 | 6.8 | 3.2 | 4.3 |
| 63026 | N. Cumberland Hydro | 0.6 | 8.6 | 3.9 | 4.3 |
| 63040 | 435 James St. South | 0.9 | 4.8 | 2.7 | 4.3 |
| 63046 | Montreal Street | 4.4 | 9.2 | 6.1 | 6.6 |
| 63047 | Totem Trailer Court | 2.7 | 10.0 | 5.9 | 5.2 |
| 63052 | Thunder Bay Transit | 0.8 | 8.6 | 3.5 | 4.1 |

[a]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 23. Average dustfall ($g/m^2/30$ days), Thunder Bay, 1973-1980.

| Station | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|
| 63003 | 7.7[a] | 7.4 | 4.6 | 4.2 | 4.7 | 4.8 | 3.8 | 4.0 |
| 63005 | 5.3 | 5.3 | 4.9 | 3.5 | 5.0 | 3.8 | 3.8 | 4.0 |
| 63012 | 4.9 | 4.6 | 3.5 | 3.5 | 3.6 | 3.7 | 2.7 | 2.8 |
| 63019 | 3.5 | 7.0 | 3.5 | 4.2 | 3.8 | 4.0 | 3.4 | 3.4 |
| 63021 | 5.3 | 5.3 | 6.7 | 5.6 | 4.6 | 4.3 | 4.2 | 2.5 |
| 63022 | 5.3 | 5.6 | 4.2 | 3.9 | 3.7 | 3.5 | 3.6 | 3.4 |
| 63024 | 13.0 | 10.2 | 7.7 | 5.3 | 4.4 | 5.3 | 4.4 | 4.4 |
| 63025 | 6.7 | 4.6 | 4.6 | 3.9 | 3.8 | 3.2 | 3.1 | 3.2 |
| 63026 | 8.8 | 6.7 | 6.0 | 5.6 | 4.9 | 4.9 | 3.3 | 3.9 |
| Average, all sites | 6.7 | 6.3 | 5.1 | 4.4 | 4.3 | 4.2 | 3.6 | 3.5 |
| Sites above objective(%) | 89 | 78 | 44 | 33 | 33 | 33 | nil | nil |

[a]Values exceeding maximum acceptable level of 4.6 (annual average) are underlined.

TABLE 24. Total suspended particulate matter (μg/m³), Thunder Bay, 1980.

| Station | Number of samples | Annual geometric mean | Number of samples above 120 μg/m³ | Maximum 24-hour value |
|---|---|---|---|---|
| 63005 | 57 | 44 | 5 | 162[a] |
| 63012 | 56 | 32 | 4 | 194 |
| 63022 | 60 | 47 | 6 | 277 |
| 63040 | 52 | 44 | 2 | 152 |
| 63046 | 51 | 63 | 8 | 274 |
| 63052 | 52 | 60 | 9 | 353 |

[a]Values exceeding the maximum acceptable limit of 120 μg/m³ (24-hour average) or 60 μg/m³ (annual geometric mean) are underlined.

TABLE 25. Average annual concentrations (μg/m³) of suspended particulate matter, Thunder Bay, 1973-1980.

| Station | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|
| 63005 | 69[a] | 61 | 51 | 49 | 47 | 44 | 51 | 44 |
| 63012 | 59 | 51 | 47 | 47 | 40 | 37 | 26 | 32 |
| 63022 | 74 | 60 | 55 | 66 | 49 | 42 | 39 | 47 |
| 63052[b] | 107 | 102 | 85 | 82 | 69 | 56 | 95 | 60 |
| Averages | 77 | 68 | 60 | 61 | 51 | 45 | 53 | 46 |

[a]Values exceeding the maximum acceptable limit of 60 μg/m³ (annual geometric mean) are underlined.

[b]Relocated in January, 1980, from station 63017.

TABLE 26. Summary of sulphur dioxide concentrations (ppm[a]) in Thunder Bay, 1980[b].

| Station | Location | Annual average | Maximum for 1-hour | Maximum for 24-hours |
|---|---|---|---|---|
| 63022 | St. Joseph's Hospital | 0.001 | 0.10 | 0.01 |
| 63040 | 435 S. James Street | 0.001 | 0.16 | 0.02 |
| 63041 | Mt. McKay | | 0.18 | 0.02 |
| 63042 | East End | | 0.13 | 0.02 |
| 63044 | James St./Kam River | | 0.17 | 0.02 |
| 63048 | Ford Street | | 0.13 | 0.01 |
| 63049 | Chippewa Park | | 0.08 | 0.02 |
| 63050 | Paipoonge | | 0.03 | <0.01 |
| 63051 | John Street Landfill | | 0.03 | <0.01 |

[a]Parts of sulphur dioxide per million parts of air, by volume.

[b]12 months of data for station 63049; 11 months for 63042 and 63048, 8 months for 63044 and 63050, 6 months for 63041, and 3 months for 63051.

TABLE 27. Summary of total reduced sulphur concentrations (ppb[a]), station 63046, Thunder Bay, 1977-1980.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of times above guideline |
|---|---|---|---|---|
| 1977 | 298 | 1.5 | 56 | 17 |
| 1978 | 280 | 1.9 | 48 | 28 |
| 1979 | 218 | 2.6 | 58 | 26 |
| 1980 | 220 | 2.9 | 131 | 90 |

[a]Parts of total reduced sulphur, expressed as hydrogen sulphide, per billion parts of air, by volume.